

THE UNO AVIATION MONOGRAPH SERIES

UNOAI Report 04-2

**Aeronautics Education, Research, and Industry
Alliance (AERIAL) Progress Report and
Proposal for Funding Continuation
NASA Nebraska EPSCoR**

**Brent Bowen
et al.**

May 2004

**UNO
Aviation Institute
University of Nebraska at Omaha
Omaha, NE 68182-0508**

Contributing Authors

Mary Fink
George Gogos
Massoum Moussavi
Jocelyn Nickerson
Donald Rundquist
Valerie Russell
Scott Tarry

© 2004, Aviation Institute, University of Nebraska at Omaha

UNO Aviation Institute Monograph Series

Michaela M. Schaaf, *Series Editor*
Mary M. Fink, *Production Manager*
Amy L. Tegeder, *Production Assistant*

Host Organization

*The University of Nebraska at Omaha, Dr. Nancy Belck, Chancellor
College of Public Affairs and Community Service, Dr. B. J. Reed, Dean
School of Public Administration, Dr. Russell Smith, Director
Aviation Institute, Dr. Brent D. Bowen, Director*

Funding Support

*NASA National Space Grant College and Fellowship Program & NASA EPSCoR,
Ms. Diane DeTroye, Acting Program Manager
NASA Nebraska Space Grant & EPSCoR Programs, Dr. Brent D. Bowen, Director*

Publication

The UNO Aviation Institute Monograph Series is published at the University of Nebraska at Omaha, 6001 Dodge Street, Omaha, NE 68182.

Published as a not-for-profit service of the Aviation Institute. Funded in part by a grant from the NASA National Space Grant College and Fellowship Program.

The University of Nebraska does not discriminate in its academic, employment or admission policies and abides by all federal, state, and regental regulations pertaining to same.

The University of Nebraska at Omaha

Aviation Institute

Monograph Series

Mission

The UNO Aviation Institute Monograph Series began in 1994 as a key component of the education outreach and information transfer missions of the Aviation Institute and the NASA Nebraska Space Grant & EPSCoR Programs. The series is an outlet for aviation materials to be indexed and disseminated through an efficient medium. Publications are welcome in all aspects of aviation. Publication formats may include, but are not limited to, conference proceedings, bibliographies, research reports, manuals, technical reports, and other documents that should be archived and indexed for future reference by the aviation and world wide communities.

Submissions

Aviation industry practitioners, educators, researchers, and others are invited to submit documents for review and possible publication in the monograph series. The required information is listed in the Submission Form, found on the world wide web at: www.unomaha.edu/~nasa/researchers/monograph.htm

Dissemination

The UNO Aviation Institute Monograph Series is indexed in various databases such as National Transportation Library (NTL), Educational Research Information Clearinghouse (ERIC), Transportation Research Information Services (TRIS), Aviation TradeScan, NASA Scientific & Technical Reports (STAR), and the Library of Congress. The series is also cataloged in the UNO Library, which is a member of the Online Computer Library Center (OCLC), an international bibliographic utility. OCLC's Union Catalog is accessible world wide and is used by researchers via electronic database services EPIC and FirstSearch and is also used for interlibrary loans. In addition, copies have been provided to the University of Nebraska - Lincoln and the University of Nebraska at Kearney Libraries. Copies are also provided to the Nebraska Library Commission, the official archive of state publications.

Ordering

UNO Aviation Institute monographs are available from the UNO Aviation Institute, Allwine Hall 422, 6001 Dodge Street, Omaha, NE 68182-0508. Order information is also available on the world wide web at www.unomaha.edu/~nasa/researchers/monograph.htm

University of Nebraska at Omaha Aviation Institute

Aviation Monograph Series

Recent monographs in the series include:

- 04-2 Aeronautics Education, Research, and Industry Alliance (AERIAL) Progress Report and Proposal for Funding Continuation - NASA Nebraska EPSCoR
- 04-1 The Airline Quality Rating 2004
- 03-5 thru 03-10 The Conference Proceedings of the 2003 Air Transport Research Society (ATRS) World Conference
- 03-4 Aerospace Workforce Development: The Nebraska Proposal; and Native View Connections: A Multi-Consortium Workforce Development Proposal
- 03-3 Fifteen Years of Collaborative Innovation and Achievement: NASA Nebraska Space Grant Consortium 15-Year Program Performance and Results Report
- 03-2 Aeronautics Education, Research, and Industry Alliance (AERIAL) Year 2 Report and Year 3 Proposal
- 03-1 The Airline Quality Rating 2003
- 02-7 The Aeronautics Education, Research, and Industry Alliance (AERIAL) 2002 Report
- 02-6 The Family Science Starter Kit: A Manual to Assist You in the Development of a Family Aeronautical Science Program
- 02-5 Partnership and the Revitalization of Aviation: A Study of the Advanced General Aviation Transport Experiments Program, 1994-2001
- 02-4 The Proceedings of the NASA Aerospace Technology Symposium 2002
- 02-3 A Summary Enabling Technology for the Small Transportation Aircraft

A complete listing of monographs is available at www.unomaha.edu/~nasa/researchers/monograph.htm

To Obtain Monographs

Complete this form and include a check or purchase order made payable to the Aviation Institute. Orders within the U.S. are \$7.50 (U.S.) per monograph, and international orders are \$10.00 (U.S.) to cover the costs of printing, shipping, and handling. Allow 4-6 weeks for delivery. Please forward this request to: *Aviation Institute, University of Nebraska at Omaha, 6001 Dodge Street, Omaha, NE 68182-0508*. Phone: 402-554-3424 or 1-800-3 FLY UNO; Fax: 402-554-3781; E-mail: nasa@unomaha.edu. You may also order online at www.unomaha.edu/~nasa/researchers/monograph.htm

Name _____

Company _____

Address _____

City, St., Zip _____

Country _____

Phone _____ E-mail _____

Quantity	Monograph #	Unit Cost	Total Cost
			\$
			\$
			\$
TOTAL ENCLOSED			\$

This series is co-sponsored by the NASA Nebraska Space Grant Consortium

Aeronautics Education, Research, and Industry Alliance (AERIAL) Progress Report and Proposal for Funding Continuation NASA Nebraska EPSCoR

Cooperative Agreement #: NCC5-572



Cooperative State Research,
Education and Extension Service
Research, Education, and Extension



ISSEarthKAM

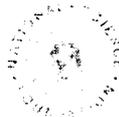
Nebraska Space Grant
& EPSCoR



UNIVERSITY OF
Nebraska



Native IMAGE



Little Priest Tribal College



Submitted Friday, April 30, 2004

Dr. Brent D. Bowen, Director
NASA Nebraska Space Grant & EPSCoR
University of Nebraska at Omaha
6001 Dodge Street
Omaha, NE 68182
(402) 554-3772
nasa@unomaha.edu
<http://nasa.unomaha.edu>



Aeronautics Education, Research, and Industry Alliance (AERIAL) Year 3 Comprehensive Summary Report of Progress

Program Overview

The Aeronautics Education, Research, and Industry Alliance (AERIAL), which began as a comprehensive, multi-faceted NASA EPSCoR 2000 initiative, has contributed substantially to the strategic research and technology priorities of NASA, while intensifying Nebraska's rapidly growing aeronautics research and development endeavors. AERIAL has enabled Nebraska researchers to: (a) continue strengthening their collaborative relationships with NASA Field Centers, Codes, and Enterprises; (b) increase the capacity of higher education throughout Nebraska to invigorate and expand aeronautics research; and (c) expedite the development of aeronautics-related research infrastructure and industry in the state. Nebraska has placed emphasis on successfully securing additional funds from non-EPSCoR and non-NASA sources. AERIAL researchers have aggressively pursued additional funding opportunities offered by NASA, industry, and other agencies. This report contains a summary of AERIAL's activities and accomplishments during its first three years of implementation.

AERIAL is housed in the Division of Aeronautics and Transportation Policy and Research facilities at the University of Nebraska at Omaha's (UNO) Aviation Institute. NASA Nebraska EPSCoR's structure has been well-suited to manage the interrelated nature of AERIAL's goals and programmatic objectives, the varied interests of AERIAL stakeholders, and the statewide emphasis of its mission. AERIAL personnel work synergistically with Nebraska's NSF EPSCoR program. AERIAL utilizes the existing NASA Nebraska EPSCoR management structure – a structure that has a proven track record of success with NASA and a demonstrated commitment to aeronautics and space science. This structure efficiently and effectively manages AERIAL's goals and objectives, the varied interests of AERIAL stakeholders, and the statewide emphases of its mission.

The administration of AERIAL continues to focus on the achievement of program goals and objectives, including ongoing identification of collaborative research opportunities with NASA personnel, the support of AERIAL's research endeavors, the building of Nebraska's aerospace infrastructure, technology transfer, the implementation of outreach activities, and increased inclusion of Native Americans in all program activities. The AERIAL strategic planning process is ongoing as well, and is reviewed at the semi-annual meetings of the Technical Advisory Committee (TAC).

As AERIAL staff and researchers complete their third year of work, they look forward to achieving long-term systemic growth in Nebraska's aerospace research and industry. Such development will be evident long after NASA funding ceases. Progress toward this end has already begun through the cultivation of innovative research and collaborations. Continued success of the AERIAL collaborative research teams (CRTs) is anticipated through increased levels of refereed publications, invited presentations, and development of patents. The cumulative success of the last three years brings the expectation of continued development and collaborations. The CRTs will continue to receive support and encouragement from AERIAL leaders in their effort to provide long-lasting, impacting services for the aviation industry.

1. Investigators' Research Successes

A. Articles Accepted or Published in Refereed Journals

- Nickerson, J., Bowen, B., & Lehrer, H. (in process). A process plan for consensus building in the evaluation of the NSGC & EPSCoR Native American outreach program. Accepted for publication in *Public Administration & Management*: Harrisburg, PA.
- Scarpellini, N., & Bowen, B. (Winter 2004). AGATE outcomes analysis: Laying the foundation for the Small Aircraft Transportation System. *Journal of Aviation/Aerospace Education and Research*. Accepted, in-process.
- Bowen, B., Headley, D., & Lu, C. (2003, January). Benchmarking airline service performance: A reference point for airline and government evaluation. *Public Works Management and Policy*, 7(3), 188-205.
- Nickerson, J., Moussavi, M., Bowen, B., Smith, R., & Tarry, S. (2002). Innovatively saving the future of transportation: The small aircraft transportation system. *Journal of Public Transportation*, 5(3), 67-84.
- Bonkiewicz, T., & Bowen, B. (2002, October). Analytic assessment of general aviation security issues in the post 9-11 environment: Implications for the Small Aircraft Transportation System. *Collegiate Aviation Review*, 20(1), 17-28.
- Bowen, B., Fink, M., Freeman, A., & Scarpellini, N. (2001). Accreditation of collegiate aviation's distance education programs: Now and in the future. *Journal of Aviation/Aerospace Education and Research*, 11(1), 21-31.
- Scarpellini, N., & Bowen, B. (2001). Evaluation and action: Sustaining excellence in collegiate aviation distance education. *Collegiate Aviation Review*, 19(1), 140-167.

B. List of Talks, Presentations, or Abstracts at Professional Meetings

- Vlasek, K., Lehrer, H., Bowen, B., & Webb, C. (2004). *Utilizing geospatial technologies on Nebraska's Native American Reservations: A case study*. Omaha, NE: University of Nebraska.
- Vlasek, K., & Webb, C. (2004, August). *GIS at a tribal college: The Native IMAGE case study*. Paper to be presented at the 2004 Environmental Systems Research Institute Annual Education Users Conference, San Diego, CA.
- Vlasek, K. (2004, May). *Utilizing Hyperspectral remote sensing on the Winnebago Indian Reservation in Winnebago, NE*. [Abstract]. To be presented in the proceedings of the American Society for Photogrammetry and Remote Sensing, Denver, CO.
- Vlasek, K., & Webb, C. (2004, May). *Utilizing Hyperspectral remote sensing on the Winnebago Indian Reservation in Winnebago, Nebraska*. Poster to be presented at the 2004 ASPRS Conference, Denver, CO.
- Bowen, B., Vlasek, K., & Webb, C. (2004, April 16). *An assessment of remote sensing applications in remote sensing*. Paper presented at the 124th Annual Nebraska Academy of Sciences Annual: Lincoln, NE.
- Chiu, A., & Bowen, B. (2004, April 16). *The objective of aviation management programs at four-year universities to meet industry demand*. Poster presented at the 124th Annual Nebraska Academy of Sciences: Lincoln, NE.
- Lehrer, H., Nickerson, J., & Vlasek, K. (2004, April 16). *Family geoscience: Providing education, equipment, and opportunities*. Poster presented at the 124th Annual Nebraska Academy of Sciences: Lincoln, NE.

- Nickerson, J., Bronson, B., Larson, M., Vlasek, K., Burbach, R., & Kenefick, T. (2004, April 16). *Contributing to NASA's workforce development initiative: 2003 Native American Aviation and aerospace day*. Poster presented at the 124th Annual Nebraska Academy of Sciences: Lincoln, NE.
- Vlasek, K. (2004, April). The creation of the Nebraska geospatial extension program. To be presented at the 1st annual Geospatial Extension Specialists Meeting, Kansas City, MO.
- Vlasek, K., & Webb, C. (2004, April 16). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. Poster presented at the 124th Annual Nebraska Academy of Sciences: Lincoln, NE.
- Bowen, B., Vlasek, K., & Webb, C. (2004, March). *An assessment of remote sensing applications in transportation*. Paper presented at the 2004 Transportation Research Forum, Evanston, IL.
- Vlasek, K., & Webb, C. (2004, March). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. Poster presented at the 2004 Association of American Geographers Annual Meeting, Philadelphia, PA.
- Vlasek, K., & Webb, C. (2004, March). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. [Abstract]. Proceedings of the Association of American Geographers Conference, Philadelphia, PA.
- Vlasek, K., Lehrer, H., Bowen, B., Webb, C. (2003). *Utilizing geospatial technologies on Nebraska's Native American Reservations: A case study*. Omaha, NE: University of Nebraska.
- Vlasek, K. (2003, November). *The Nebraska geospatial extension program*. Poster presented at the Northeast Community College GIS Day, Norfolk, NE.
- Vlasek, K. (2003, November). *Native IMAGE: (Institute for managing applications in geospatial extension): A Nebraska Geospatial Extension Initiative*. Poster presented at the Northeast Community College GIS Day, Norfolk, NE.
- Vlasek, K. (2003, October). *The Nebraska geospatial extension program: Program initiatives*. Presented at the On-Target Seminar, Salt Lake City, UT.
- Nickerson, J., & Vlasek, K. (2003, September). *Careers in aeronautics and the geosciences*. Native American Aviation and Aerospace Day, Wayne, NE.
- Vlasek, K. (2003, September). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Poster presentation at the 2003 Midwest ArcUsers Group Conference, Omaha, NE.
- Vlasek, K. (2003, September). *The Nebraska geospatial extension program: Working with Space Grant*. Presented at the Western Region Space Grant Meeting, Rapid City, SD.
- Vlasek, K. (2003, June). *Nebraska's geospatial extension program*. Paper presented at the Nebraska GIS/LIS Omaha User's Group Meeting, Omaha, NE.
- Vlasek, K. (2003, May). *Nebraska's geospatial program*. Paper presented at the 2003 Nebraska GIS Symposium, Lincoln, NE.
- Vlasek, K., Nickerson, J., & Schaaf, M. (2003, May). *Grant writing for the GIS professional*. Short course delivered at the 2003 Nebraska GIS Symposium, Lincoln, NE.
- Lehrer, H., & Vlasek, K. (2003, April). *Native American geospatial outreach*. Paper presented at the Univ. of Redlands and Environmental Research Systems Institute: Redlands, CA.

- Vlasek, K., & Lehrer, H. (2003, April). Native IMAGE (Institute for Managing Applications in Geospatial Extension) [Abstract]. *Proceedings of the 123rd Nebraska Academy of Sciences*, 33.
- Vlasek, K., & Lehrer, H. (2003, April). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Poster presented at the 123rd Annual Meeting of the Nebraska Academy of Sciences, Lincoln, NE.
- Bowen, B., Lehrer, H., Brown, S., Nickerson, J., & Vlasek, K. (2003, March). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Paper presented at the NASA EPSCoR Director's Meeting, Washington, D.C.
- Bowen, B., Vlasek, K., & Webb, C. (2003, March). *An assessment of remote sensing applications in transportation*. Paper to be presented at the 2004 Transportation Research Forum, Evanston, IL.
- Trimm, J., Vlasek, K., Bowen, B. (2002). *Existing geospatial programs at American Indian colleges*. Omaha, NE: University of Nebraska at Omaha Aviation Institute.
- Vlasek, K., Bowen, B., & Schaaf, M. (2002, December). *Nebraska's geospatial extension program*. Paper presented at the NASA Nebraska Space Grant and EPSCoR Technical Advisory Committee Meeting, Lincoln, NE.
- Lehrer, H., & Vlasek, K. (2002, October). *Santee Sioux geospatial demonstration project*. Project presented at Santee Geospatial Science Night, Santee, NE.
- Vlasek, K. (2002, October). *Integrating science and Native American culture*. Poster presentation at the National Council of Space Grant Directors Fall Meeting, Dorado, Puerto Rico.
- Vlasek, K., Bowen, B., & Schaaf, M. (2002, October). *Nebraska's geospatial extension program*. Paper presented at the National Council of Space Grant Directors Fall Meeting, Dorado, Puerto Rico.
- Lehrer, H., Nickerson, J., & Vlasek, K. (2002, October). *Santee Sioux Family Geospatial Science Night*. Workshop developed and delivered on the Santee Sioux Reservation, Santee, NE.

C. List of Patents

No patents were pursued by NSGC & EPSCoR administrative staff.

D. Follow-on Grant Proposals Submitted and Funded (including NASA awards)

- Throughout the first three years of funding, the AERIAL leadership team pursued grants through five additional funding opportunities, four of which were awarded. These proposals were submitted to:
 - National Science Foundation,
 - Aerospace States Association,
 - National Space Grant College and Fellowship Program
- As a result of these awards, Nebraska is now the top-funded NASA Space Grant & EPSCoR institution. These grants provide collaboration between AERIAL and the NSGC.
- Additional funding pursued during AERIAL's first three years totaled \$820,374, with \$520,374 successfully awarded.

National Science Foundation (NSF)

- In 2002, NSF awarded the Nebraska Native American outreach team \$9,124 for a grant titled "Nebraska EPSCoR Infrastructure Improvement Grant."

- This funding was used for the development of a research partnership between Nebraska EPSCoR and Nebraska's tribal colleges.
- AERIAL personnel also utilized a portion of this grant to develop and present a comprehensive "Grant Writing Workshop" for Little Priest Tribal College (LPTC), Nebraska Indian Community College, Nebraska Native American Public School Systems, and other members of Nebraska's Native American population.
- Members of Nebraska's Native American outreach team continue to pursue additional funding opportunities to assist in achieving the NASA-directed goals they have set for their group, collaborating and seeking collaboration with projects and opportunities that will assist in the expansion and development of Native IMAGE.
 - One such opportunity is through Nebraska EPSCoR, which would allocate \$15,000 over a three-year period for enhancement of science and computer labs and development of interdisciplinary degree and certificate programs in GIS at LPTC. Results of this award are pending.
 - In 2002, the NNAOP team also pursued an NSF Opportunities for Enhancing Diversity in the Geosciences grant titled "Geoscience Education Opportunities on the Winnebago Indian Reservation" for \$300,000 which was not selected for funding.

Aerospace States Association

- An award secured through the Aerospace States Association's Mathematics, Science and Technology Education (MSTE) grants provided \$29,000 for a grant entitled "Families United (FUN) in the Discovery of Mathematics, Science, and Technology: Systemic Initiative to Improve MSTE Skills of Nebraska's Native American Youth."
 - This award provided funds to AERIAL researchers who work directly with teachers in Nebraska's Native American educational systems.
 - This MSTE grant was originally awarded during NIARID (predecessor of AERIAL), however AERIAL researchers directed the grant's initiatives to fruition.

NASA Space Grant

- Grants were successfully obtained in 2002 and awarded through NASA Space Grant. These included
 - Nebraska's upgrade to "Designated" status (\$218,750)
 - Workforce Development grant (\$82,500).
- In 2003, NSGC pursued and was competitively selected to receive additional workforce development funding.
 - Nebraska was awarded \$91,000 for its single-state proposal and (\$25,000) for its multi-state collaborative proposal.

United States Department of Agriculture

- In 2003, GES Vlasek submitted a proposal to the USDA for \$50,000 to support the development of a Native Geospatial Extension Model (GEM). Results of this award are pending.

E. Improvements in State Research and Development Infrastructure

Nebraska has utilized its core funding to: (a) foster the initiation of new contacts with NASA Field Centers and Enterprises and to support the collaborative relationships between Nebraska and NASA researchers in areas outside of the three CRT components; and (b) build additional human and information infrastructure that will ensure the sustained growth of the state's aeronautics research and industry after NASA funding ends. An emphasis on face-to-face, on-site meetings with personnel from NASA Field Centers and Strategic Enterprise Offices at NASA Headquarters serves as the cornerstone for these objectives. The NASA Nebraska/AERIAL director and other AERIAL staff have met at least once each year with NASA EPSCoR personnel at NASA Headquarters and University Affairs Officers at collaborating NASA Field Centers. By timing these meetings to occur after the completion of progress reports but before TAC meetings, AERIAL is assured that NASA feedback on AERIAL performance is addressed during TAC meetings. Additional contact with NASA Center personnel is documented in Attachment 1.

Since 2000, key personnel from the three CRTs have made at least one visit per year to collaborating Field Centers. Additional meetings are scheduled at academic conferences or symposia where Nebraska and their respective NASA collaborators are in attendance. NASA researchers have been and are invited to visit Nebraska to meet with AERIAL administrators and/or CRT faculty researchers and students.

AERIAL staff members Jocelyn Nickerson and Mary Fink attended the NSF/EPSCoR Annual Conferences in 2002 and 2003, respectively. This conference increased awareness of and instituted contact with various EPSCoR-funded organizations and researchers. Various opportunities for federal collaborations were also realized.

In a continuing effort to strengthen AERIAL ties to national NASA personnel, each AERIAL CRT, as well as the Native IMAGE (Institute for Managing Applications of Geospatial Extension) seed research program, participated in the first-ever National NASA EPSCoR Conference in Washington, D.C., in March 2003. CRT and seed research leaders highlighted their innovative research through poster presentations. Additionally, Dr. Brent Bowen hosted a panel session at the conference on working with NASA Centers.

A meeting of all state Geospatial Extension Specialists (GES) was held in Kansas City, MO, during April 2004. All were invited to present their individual state's best practices during a round-table discussion. This was the first meeting of its kind; future meetings are planned. Nebraska is pursuing collaboration with specific GES personnel (right), who communicate and contribute to ideas on the GES listserve.

Through Nebraska's Geospatial Extension Program, numerous collaborations have been established with NASA Centers including Stennis Space Center, Goddard Space Center, Johnson Space Center, Jet Propulsion Laboratory, and Dryden Flight Research Center. Contact was made with Stennis Space Center at the "Operation On-Target Seminar" in October 2003 in Salt Lake City. Dr. Keith Morris has offered to assist the Nebraska Geospatial Extension Program. From the Lockheed Martin side at Stennis Space Center, he works with Doc Smoot and Lloyd McGregor, and is currently committed to NASA's Ag 20/20 program. Nebraska GES Vlasek also maintains

Nebraska's GES Collaborative Contacts

State	GES
Connecticut (EPSCoR State)	Dr. Sandy Prisole
Utah	Dr. Phil Rasmussen
New Hampshire (EPSCoR State)	Anne Deely
Virginia	Dr. John McGee
Arizona	Dr. Barron Orr
Mississippi (EPSCoR State)	Dr. Scott Samson
North Dakota (EPSCoR State)	Dr. John Nowatzki
Oklahoma (EPSCoR State)	Dr. May Yuan
Ohio	Nathan Watermeier
Alabama	Dr. Paul Mask

collaborative contact with her technical monitor, Dr. Marco Gerodina, of the Earth Observation Research Office at Stennis Space Center. A comprehensive listing of NASA Center Collaboration with AERIAL's individual researchers is shown in Attachment 2.

Through AERIAL, grants are available for travel to NASA research and field centers to support collaboration-building activities impacting the state research and development infrastructure. AERIAL has given priority to faculty who are not members of the three CRTs but wish to pursue new NASA collaborations. Travel grants have fostered collaborative relationships at Johnson Space Center, Dryden Flight Research Center, Stennis Space Center, Kennedy Space Center, and Ames Research Center. The following list itemizes individual investigators' specific collaboration-building activities supported through travel funding:

2001

2001 – Dr. Richard Box, professor, and Pat O'Neil, doctoral fellow, to NASA's Kennedy Space Center – to establish collaboration for their research involving spaceports.

2002

Nov. 2002 – Scott Vlasek, NASA Nebraska Space Grant Consortium (NSGC) & EPSCoR Manager of Technology-Based Educational Systems to the Association for Continuing Higher Education (ACHE) Conference in Birmingham, AL – accepted the Distinguished Credit Award for the NSGC & EPSCoR-supported aviation undergraduate distance education program, an education outreach component he supervises

Nov. 2002 – Scott Vlasek, in collaboration with Denny Acheson of the UNO Aviation Institute; and Melba Acheson, Larry Winkler, and Karen Garver, of the UNO College of Continuing Studies, to ACHE Conference in Birmingham, AL – presented research titled "Success with an On-Line Degree Completion Program: Teamwork within an Institution"

2003

March 2003 – Todd Bonkiewicz, graduate fellow, and Pat O'Neil, doctoral fellow, to Washington, D.C. – to participate in the Transportation Research Forum Conference.

March 2003 – Dr. Dan Pope, Convective Extinction of Fuel Droplets (CEFD) CRT researcher, to Chicago for the 3rd Joint Meeting of the U.S. Sections of the Combustion Institute.

April 2003 – Karisa Vlasek and Jocelyn Nickerson to Annual Native Schools Science Fair at Winnebago Public School in Winnebago, NE – served as judges for elementary and high school science projects that were created by Santee, Walthill, and Winnebago students (right).

Sept. 2003 – AERIAL Assistant Director Michaela Schaaf to Western Regional Space Grant Meeting in Rapid City, SD – led a discussion on Workforce Development progress.

Sept. 2003 – Karisa Vlasek to Midwest Arc Users Group, Omaha, NE – Poster presentation (won honorable mention)



- Oct. 2003 – Karisa Vlasek to Operation “On-Target” Seminar, Salt Lake City, UT, –
Presentation on Nebraska Geospatial Extension Program (NEGEP)
- Nov. 2003 – Karisa Vlasek to International Symposium on Remote Sensing of the Environment,
Honolulu, HI
- Nov. 2003 – Karisa Vlasek and Cindy Webb to Northeast Community College GIS Day,
Norfolk, NE – 2 poster presentations
- Dec. 2003 – Mike Larson to Aerospace Technology Working Group Symposium

Conferences/Meetings Attended for 2003 Reporting Period:

- UN Cooperative Extension Midsummer Diagnostic Clinic, Mead, NE
- Nebraska State Data Center Conference, Omaha, NE
- Midwest Arc User’s Group Meeting, Omaha, NE
- NativeView Meeting, Sioux Falls, SD
- Operation On-Target Seminar, Salt Lake City, UT
- NASA Nebraska Space Grant Western Region Meeting, Rapid City, SD

2004

- March 2004 - Association of American Geographers – Karisa Vlasek and Cindy Webb in
Philadelphia, PA co-presented on NEGEP initiatives and progress (dissemination of
research outcomes).
- March 2004 – Transportation Research Forum – Pat O’Neil, AERIAL doctoral fellow in
Chicago, IL, presented AERIAL-related outcomes
- March 2004 – Karisa Vlasek to Transportation Research Forum, Evanston, IL – to present
Nebraska research and encourage collaboration.
- March 2004 – Transportation Research Forum – Scott Tarry and Stuart Cooke assembled TSAA
WG panel presentation
- March 2004 – Karisa Vlasek again served as a judge at the Annual Native Schools Science Fair
- April 2004 – Jan Bingen and Hank Lehrer American Association of Community Colleges
presentation

Abstract Submissions for 2004 Reporting Period:

- Association of American Geographers Annual Meeting, Philadelphia, PA - Poster presentation
- Transportation Research Forum, Evanston, IL - Paper presentation
- American Society for Photogrammetry & Remote Sensing Annual Conference, Denver, CO -
Poster presentation
- Soil and Water Conservation Society Annual Meeting, St. Paul, MN - Panel session and poster
presentation
- 1st Annual Geospatial Extension Specialist Meeting, Durham, NH - Paper presentation
- ESRI Conference, San Diego, CA - Paper presentation

Conferences/Meetings Attended for 2004 Reporting Period:

- International Symposium on Remote Sensing of the Environment, Honolulu, HI
- Nebraska Corn Expo, Fremont, NE
- Nebraska GIS Steering Committee Meeting, Lincoln, NE
- UN Cooperative Extension Aerial Imagery Workshop, Mead, NE

Nebraska Agricultural Technologies Association Annual Meeting, Grand Island, NE
Winnebago visit with EPA/Tribal Planning Office, Winnebago, NE

Nebraska's Geospatial Extension Program contributes to AERIAL's collaborative philosophy toward improving state research and development infrastructure. Below is a comprehensive listing of applicable NEGEP training, workshops, and conference participation.

Nebraska Geospatial Extension Program Training, Workshops, and Conference Participation

Nebraska GIS Symposium, Lincoln, NE, 2003	NASA-Sponsored Earth Grant Meeting, Storrs, CT, 2002
Western Region Space Grant Meeting, Rapid City, SD, 2003	NASA Nebraska Space Grant & EPSCoR collaboration building meeting with Little Priest Tribal College President and Staff regarding GEOWIRE NSF proposal development, 2002
Women in Science Conference, Lincoln, NE, 2003 and 2004	Nebraska GIS/LIS Meetings and Forums, NE, 2002-2003
ASPRS Annual Conference, Anchorage, AK, 2003	Nebraska GIS/LIS Omaha User's Group Meetings, Omaha, NE, 2002-2003
Professional Airborne Digital Mapping Systems, Short Course	Nebraska GIS Steering Committee Meetings, Lincoln, NE, 2002-2003
Remote Sensing of GIS Wetlands, Short Course	Nebraska GIS I-Team Meetings, Lincoln, NE 2002-2003
Nebraska GIS Symposium, Lincoln, NE, 2003	National GIS Day Activities, Omaha, NE, 2002
Remote Sensing: An Overview of the State of the Art, Short Course	ESRI, Introduction to ArcGIS 1, San Antonio, TX, 2002
GIS in Local Government, Short Course	ESRI Introduction to ArcGIS Survey Analyst, Live Web Training Seminar, 2003
Nebraska Geospatial Extension Program, Display Booth	ESRI, Working with ArcPad Web Tutorial, 2003
123 rd Nebraska Academy of Sciences, Lincoln, NE, 2003	ESRI, Partnering for Community Action, Web Tutorial, 2003
NASA Ames Visit and Briefing, Moffett Field, CA, 2003	University of NE at Lincoln-CALMIT, Introduction to ArcExplorer and ArcView, 2002
ESRI Visit and Briefing, Redlands, CA, 2003	Research Systems Institute, Exploring ENVI, Boulder, CO, 2003
Remote Sensing Workshop, EROS Data Center/South Dakota State University, Sioux Falls, SD, 2003	Introduction to MultiSpec, EROS Data Center, Sioux Falls, SD, 2003
Precision Agriculture Workshop, Lincoln, NE, 2003	Canadian Centre for Remote Sensing, Fundamentals of Remote Sensing. Web Tutorial. 2003
NASA Stennis Space Center Visit and Briefing, MS, 2002	
GIScience Conference, Boulder, CO, 2002	
Grant Writing Seminar, Omaha, NE, 2002	
National Council of Space Grant Directors Fall Meeting, Dorado, Puerto Rico, 2002	
Preparing Students for Careers in Remote Sensing, Durham, NH, 2002	

2. Systemic Change

AERIAL has contributed to increasing the ability of Nebraska's researchers through collaboration and planning to improve the state's research capacity, as evidenced through collaborative research projects, educational outreach to Native American populations, and geospatial capacity building. A significant void existed in these areas prior to the implementation of AERIAL and its related objectives.

A. Reordered State and/or Institutional Priorities

AERIAL's Native American outreach efforts were launched in direct response to NASA's emphasis on the inclusion of underrepresented populations in NASA EPSCoR and Space Grant-funded activities. These initiatives seek to inspire Native American youth from Nebraska to pursue academic and professional careers in the aeronautics and aerospace fields. The underlying goal is the continued improvement of mathematics and science skills among these Native American youngsters.

NNAOP researchers, in collaboration with Nebraska EPSCoR, provided a grant writing workshop for teachers from Macy, Santee, Winnebago, and Walthill Public Schools; faculty from LPTC and NICC; and members of Nebraska's Native American population. The event was held at the Marina Inn in South Sioux City, NE, on November 2, 2002. Participants received materials and heard interactive lectures on applying for federal, state, and private grant funding.

Winnebago community focus groups and a literature review have identified the critical importance of greater emphasis on a seamless mathematics and science program extending from

the lower elementary grades to the tribal college. LPTC, Native IMAGE, and Winnebago Public Schools will develop such a bridge program in mathematics, science, and technology.

As part of NASA's workforce development initiative, NEGEP is partnering with CALMIT to develop a non-credit certificate program. In Nebraska, remote sensing training is only offered at the University level for credit, making this the only program in Nebraska to offer a non-credit certificate in geospatial technologies. This non-credit certificate in geospatial technologies will offer Nebraska residents an opportunity to develop or enhance skills, contributing to a stronger workforce. Funding for this project has been allocated from the 2003 NASA Workforce Development Grant, awarded in January 2004.

B. Increased Financial Commitment from State, Industry, and Participating Institutions

During the three years of AERIAL's implementation, NASA Nebraska EPSCoR has seen increased participation from its affiliate institutions. Specifically, AERIAL staff successfully secured additional facility and meeting space for its daily operations, increasing office space from ~1,550 ft.² to ~2,880 ft.². The lead institution, UNO, increased the amount of space allocated to the NASA Nebraska EPSCoR team by allowing the occupation of dedicated space in one of the university's largest buildings. LPTC is not only the primary implementing component of the NNAOP program and the cooperative institution of Native IMAGE, but also a provider of increased resources for joint initiatives with AERIAL. Nebraska has also seen an increase in the effort and commitment of in-kind human resource involvement at each affiliate institution.

3. Successful Technology Transfer to the Private Sector

AERIAL's technology transfer experts confer with many national, regional, and state technology transfer resources, including an individual at each collaborating NASA Center. Nebraska Department of Economic Development, University of Nebraska Technology Transfer Center and University of Nebraska Technology Park (UNTP) are represented on AERIAL's TAC. AERIAL expertise is augmented by NASA Regional Mid-Continent Technology Transfer Center, Director Thomas Spilker of Nebraska Industrial Competitiveness Services at University of Nebraska-Lincoln, Marianne Clarke from the Great Lakes Industrial Technology Center and President Joseph P. Allen of Robert Byrd National Technology Transfer Center in Wheeling, WV. Collaboration with UNTP yielded an internship program for UNO aviation students.

A joint NASA Nebraska EPSCoR/AERIAL website, CD-ROM technology, and distance education disseminate AERIAL's research. The website¹ includes grant announcements, listings of published research, and program descriptions. AERIAL staff developed a CD-ROM featuring Journal of Air Transportation articles². Staff also collaborated on the production of 1,000 DataSlate CDs for nationwide distribution. The award-winning software targeting K-12 allows users to easily navigate and simultaneously overlay large imagery data sets.

AERIAL collaborations have resulted in placement of Geospatial Data Centers across Nebraska. The first data center was placed at Native IMAGE on the LPTC campus in 2002 in Winnebago, NE. Geospatial software was placed on the UNO campus data center in February 2003, archiving Nebraska airborne remote sensing missions and providing access to geospatial journals and magazines. Native IMAGE's extensive geospatial data supplies the Winnebago tribe with geospatial information regarding well mapping, pastoral and agricultural land-use,

¹ <http://nasa.unomaha.edu>

² <http://jat.unomaha.edu>

precision farming, and grazing management. Specialized geospatial workshops and training programs focus on GIS, remote sensing, and GPS technology.

4. Collaboration Development with State Agencies, Industry, Research/Academic Institutions, and NASA

Nebraska led the successfully-funded 2003 Multi-State Workforce Development Proposal in collaboration with ID, ND, SD, OR, WY, and UT Space Grant Consortiums. GeoSTAC (Geospatial Training and Analysis Cooperative) between the NE, ID, and HI Space Grant Consortiums develops remote sensing training programs for those states. Attachment 2 contains a comprehensive list of NASA Center Collaboration.

Collaboration with NH Geospatial Extension Program, Space Grant and Sea Grant consortiums include sharing geospatial workshop modules, developing a geospatial career brochure, and organizing all the states' GES to meet at the Annual ESRI User's Conference. AERIAL collaborated with MN Sea Grant (MSG) to collect hyperspectral data from Perch Lake using the AISA-mounted sensor, web-deliver an educational module on remote sensing and water, and develop the NEGEP brochure. Over 500 were distributed to geospatial contacts nationwide. AERIAL collaborated with SD Space Grant on geospatial training workshops. Student work-study and internships arose from collaboration with CALMIT and the Earth Resources Observation System Data Center.

AERIAL's collaborations with NEGEP/Native IMAGE have impacted Native American reservations statewide. Collaboration with the Winnebago Land Management and EPA Office resulted in GPS training. A partnership with Winnebago Public Schools is following the thriving Family Aeronautical Science program template. The first NE Aeronautics Education Summit (NAES) Meeting, held in South Sioux City, NE, for K-12 educators from four Native American high schools and two tribal colleges, resulted in NASA data and models utilized in other states to improve mathematics and science programs in Native American public schools.

5. Evidence of Furthering State Priorities

AERIAL employs a statewide approach to collaborative endeavors between higher education, industry, and state government. Core funding supports aeronautics-related collaborations with CALMIT, a research center established through the Nebraska Research Initiative (NRI). The Nebraska State Airport (Aviation) System Plan has developed recommendations for the state's aviation system for the next 20 years. AERIAL collaborations (including SATS) with the Nebraska Department of Aeronautics' director, civil engineer and head of flight operations evidence alignment with these state priorities. A goal of the comprehensive Nebraska Statewide Long-Range Transportation Plan is to work with the University of Nebraska in the "implementation of successful research and share findings." Nebraska State Department of Economic Development's (NDED) strategic plan states that "the State of Nebraska shall identify new ways to more effectively utilize its institutions of education for long-term economic development and diversification." The vision and strategic goals of these entities are incorporated into the AERIAL strategy. AERIAL's TAC is comprised of statewide representatives from government, industry and academic affiliates, including individuals from NDED, NRI, NE Department of Aeronautics, and Omaha Airport Authority (see *Section 8*).

Core funding supports AERIAL's collaborations with NEGEP and Native IMAGE, addressing the State's Native American Education Advisory Panel concerns about lack of community support and absence of parental involvement. Partnerships provide GIS remote sensing and GPS training at Native American reservations across the state in family-friendly formats.

6. Interaction and Cooperation with Nebraska Space Grant

As NSGC Director, Dr. Bowen provides advisory board members written and oral AERIAL progress reports. As with the AERIAL TAC, NSGC affiliate members provide recommendations regarding AERIAL activities, progress, and modifications. The NSGC Board provides feedback during the annual AERIAL performance review. Dr. Bowen's dual role as NSGC director and AERIAL director has ensured effective and efficient coordination and communication between the two organizations. This coordination is exemplified by the AERIAL strategies relating to Native American and student outreach, which dovetail (but not duplicate) existing educational outreach through the NSGC.

Native IMAGE personnel and associated NSGC staff continue to secure evaluation material regarding the effect of Nebraska's Native American Outreach Program. LPTC faculty involved with Native IMAGE presented three national papers during 2003, which fulfills a major evaluation metric of the outreach of the project. LPTC faculty members have also attended GIS training. A proposal for a presentation at the American Association of Community Colleges has been submitted and accepted for the April 2004 National Convention. Another measure of the impact of the Institute is that several modules of GIS have begun to appear in the computer science curriculum within Nebraska's Native American public schools and community colleges.

7. Personnel Information

Core member	Male	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty	4		3	1		
Post-Doctoral						
Staff	2		2			
Graduate	2		1		1	
Undergraduate						

Core member	Female	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty						
Post-Doctoral						
Staff	4		4			
Graduate	2		2			
Undergraduate						

8. Technical Advisory Committee Membership

Ms. Shelly Avery	Campus Coord., NICC	Ms. Diane Bartels	Vice President, Air Force Association
Dr. Otto Bauer	UNO Professor (ret.)	Dr. John Block	Professor, Little Priest Tribal College
Dr. Thomas Bragg	UNO Dean of Graduate Studies & Associate Vice Chancellor for Research	Mr. Ed Brogie	Executive Dir., NE Academy of Sciences
Ms. Caprice Calamaio	Campus Coord., College of St. Mary	Dr. Larry Carstenson	Chair, Dept. of Management, UNK
Dr. Fred Choobineh	Director, Nebraska EPSCoR	Ms. Christi Churchill	Strategic Air & Space Museum
Mr. James Dugan	Campus Coordinator, Hastings College	Dr. Samy Elias	Assoc. Dean, Nebraska Research Initiative
Dr. John Farr	Associate Vice Chancellor, UNO	Dr. Lynne Farr	Campus Coordinator, UNMC
Dr. Shane Farritor	Campus Coordinator, UNL	Dr. E. Terence Foster	Campus Coordinator, UNO Engineering
Mr. Stephen Frayser	President, Univ. of NE Tech. Park	Dr. Neal Grandgenett	Associate Professor, UNO
Ms. Lisa Haile	Svcs. for Students with disABILITIES	Ms. Wanda Henke	Teacher, Santee Schools
Dr. John Christensen	Vice Chancellor, UNO Acad. Affairs	Ms. Diane Hofer	Airport Project Mgr., NE Dept. of Aeronautics
Mr. James Joyce	Campus Coord., Western NE Community College	Mr. Dave Kipling	Associate, Great Plains Girl Scouts
Lt. Col. Charles Lane	99 th Pursuit Squadron, Civil Air Patrol	Mr. Louis LaRose	President, Little Priest Tribal College
Mr. Tommie Lee	Safety Engineer, 3M	Dr. Henry Lehrer	Native IMAGE, Founding Director
Brig. Gen. Roger Lempke	Nebraska National Guard	Ms. Kathleen Lodi	Nebraska 4-H Youth Development
Dr. Denise Maybank	Director of Multicultural Affairs, UNO	Dr. Jay Noren	Executive Vice President and Provost, UNL
Mr. Kent Penney	Dir., Nebraska Dept. of Aeronautics	Dr. Louis Pol	Associate Dean, UNO College of Business
Ms. Barb Rebrovich	Campus Coord., Metropolitan Community College	Dr. Betty Red Leaf	Campus Coord., Little Priest Tribal College
Mr. Robert Rose	President, Tuskegee Airmen, Inc.	Mr. Jack Ruff	Director, Business Association Division, NE Dept. of Economic Development
Dr. John Schalles	Campus Coord., Creighton University	Mr. Dave Shrader	Campus Coord., Grace University
Ms. Bonnie Schulz	Campus Coord., Northeast Community College	Dr. Lois Veath	Campus Coord., Chadron State College
Mr. Al Wendstrand	Dir., NE Dept. of Economic Develop.	Dr. Brent Bowen*	Director, NE Space Grant & EPSCoR
Ms. Mary Fink*	NE Space Grant & EPSCoR Coord.	Dr. George Gogos*	CEFD CRT Leader
Dr. Mike Larson*	Coord., Omaha Campus & Ext. Rel.	Ms. Jocelyn Nickerson*	Res. Implementation & Comm. Specialist
Dr. B.J. Reed*	Dean, CPACS, UNO	Dr. Don Rundquist*	ARS CRT Leader
Dr. Russ Smith*	Chair, School of Public Admin, UNO	Ms. Amy Tegeder*	Administrative Asst.
Dr. Scott Tarry*	SATS CRT Leader	Ms. Karisa Vlasek*	Geospatial Extension Specialist
Ms. Sara Woods*	Asst. Dean, CPACS, UNO		

*Ex-officio TAC Member

9. TAC Meeting Schedule

Each spring TAC meeting is held in conjunction with the annual Nebraska Academy of Sciences at Nebraska Wesleyan College in Lincoln, NE, where researchers and their staff are encouraged to present their studies. Additionally, the spring meeting provides the unique opportunity for each TAC member to review and comment on NASA Nebraska EPSCoR annual reports and proposals.

Each meeting of the TAC has served as an opportunity for NASA Nebraska EPSCoR representatives to report on various outcomes resulting from current research endeavors. Specifically, Dr. Bowen provides the group with an overview of the TAC charge, membership, and annual report. Each CRT presents their achievements and answered questions posed by the committee. A summary of AERIAL-sponsored research accomplishments is presented, and members provide input on AERIAL activities and meeting structure. This is a successful collaboration between a variety of intellectual institutions and industry affiliates. Outcomes from this meeting allow those associated with AERIAL to continue to strive for educational and research excellence.

Since the inaugural TAC meeting on December 7, 2001 in South Sioux City, NE, many prominent and talented members of industry and academia have enthusiastically offered their guidance and opinions regarding TAC goals and objectives. Each additional meeting and Nebraska location is listed below:

April 26, 2002	Nebraska Wesleyan College, Lincoln, NE
December 3, 2002	University of Nebraska Technology Park, Lincoln, NE
April 25, 2003	Nebraska Wesleyan College, Lincoln, NE
November 21, 2003	UNO W.H. Thompson Alumni Center, Omaha, NE
April 16, 2004	Nebraska Wesleyan College, Lincoln, NE

Attachment I
 NASA Nebraska EPSCoR Comprehensive Quantitative Research Outcomes 2001 - 2004

Universities Involved	Patents and Publications				New Grants	
	Peer Reviewed Publications	Other Publications	Presentations	Patents	New Grants	New Grants Value
17	27	51	48	0	7	520,374

Participants				Collaborations		
Undergrad Students (cum)	Grad Students (cum)	Post-Doctoral	Faculty	Collabs. w/ NASA Centers	Collabs. w/ Industry	Collabs. w/ Others
3	21	0	48	13	8	47

Attachment 2
NASA Center Collaborative Action

<u>AERIAL Personnel</u>	<u>Center Contact</u>	<u>Date of Contact</u>	<u>Place of Contact</u>
<i>Ames Research Center (ARC)</i>			
Mary Fink	Doug O'Handley	SG Dir Meeting – October 2002	Puerto Rico
Michaela Schaaf	Doug O'Handley	SG Dir Meeting – October 2002	Puerto Rico
Massoum Moussavi	Bonnie Samuelson	Teacher Programs – July 2002	ARC
Massoum Moussavi	Doug O'Handley	Astrobiology Academy – July 2002	ARC
Massoum Moussavi	Davis Lamb	Astrobiology Academy – July 2002	ARC
Massoum Moussavi	Emily Schaller	Astrobiology Academy – July 2002	ARC
Massoum Moussavi	Michael Landis	July 2002	ARC
Massoum Moussavi	David Peterson	July 2002	ARC
Massoum Moussavi	Donald James	July 2002	ARC
Massoum Moussavi	Brenda Collins	July 2002	ARC
Massoum Moussavi	Tom Clausen	July 2002	ARC
Massoum Moussavi	Susanne Ashby	July 2002	ARC
Massoum Moussavi	Deborah Bazar	July 2002	ARC
Massoum Moussavi	Michael Freeman	July 2002	ARC
Henry Lehrer	Bonnie Samuelson	April 2003	ARC
Henry Lehrer	Tom Clausen	April 2003	ARC
Henry Lehrer	Liza Alderette	April 2003	ARC
Henry Lehrer	Doug O'Handley	April 2003	ARC
Henry Lehrer	Joe Tanner	May 2002	ARC
Henry Lehrer	Michael Landis	July 2002	ARC
Henry Lehrer	David Peterson	April 2003	ARC
Henry Lehrer	Donald James	April 2003	ARC
<i>Dryden Flight Research Center (DFRC)</i>			
Michaela Schaaf	Susan Miller	SG Dir Meeting – October 2002	Puerto Rico
Mary Fink	M. Rodon-Naveira	SG Dir Meeting – October 2002	Puerto Rico
Karisa Vlasek	Susan Miller	SG Dir Meeting – October 2002	Puerto Rico
Henry Lehrer	James Lucero	May 2003	DFRC
<i>Goddard Space Flight Center (GSFC)</i>			
Karisa Vlasek	Blanche Meeson	SG Dir Meeting – October 2002	Puerto Rico
Henry Lehrer	Dave Rosage	March 2003	GSFC
Henry Lehrer	Richard Fahey	March 2003	GSFC
Ram Narayanan	K. Jon Ranson	Teleconference – March 2003	GSFC
Don Rundquist	Liping Di	Teleconference – November 2003	GSFC
Neal Grandgenett	Susan Hoban	Biannual e-mail/phone contact	GSFC
Neal Grandgenett	Sheila Humke	Quarterly e-mail/phone contact	GSFC
		Earth Science Enterprise	
<i>Jet Propulsion Laboratory (JPL)</i>			
Michaela Schaaf	Linda Rodgers	SG Dir Meeting – October 2002	Puerto Rico
Karisa Vlasek	Linda Rodgers	SG Dir Meeting – October 2002	Puerto Rico
Michaela Schaaf	Linda Rodgers	Western Region SG – September 2002	Big Sky, MT
Brent Bowen	Linda Rodgers	Teleconference – March 2003	
Henry Lehrer	Nancy Leon	April 2002	JPL
Henry Lehrer	Pat Liggett	July 2002	JPL
Neal Grandgenett	Betty Sword	Monthly e-mail/phone contact	vbl.
<i>Kennedy Space Center (KSC)</i>			
Michaela Schaaf	Gregg Buckingham	SG Dir Meeting – October 2002	Puerto Rico

Brent Bowen	Gregg Buckingham	Western Region SG – September 2002	Big Sky, MT
Michaela Schaaf	Gregg Buckingham	Western Region SG – September 2002	Big Sky, MT
Henry Lehrer	Gregg Buckingham	Western Region SG – September 2002	Big Sky, MT
Brent Bowen	L. Michael Freeman	NASA EPSCoR Meeting – Mar. 2003	Washington, DC
Brent Bowen	L. Michael Freeman	Western Region SG – September 2002	Big Sky, MT
Henry Lehrer	L. Michael Freeman	Western Region SG – September 2002	Big Sky, MT
Shane Farritor	Mike Sklar	American Institute of Aeronautics & Astronautics – April 2003	KSC
Shane Farritor	Thomas Lippitt	American Institute of Aeronautics & Astronautics – April 2003	KSC
Brent Bowen	Rita Willcoxon	February 2003	KSC
Brent Bowen	Greg Buckingham	February 2003	KSC
Brent Bowen	Renee Ponik	February 2003	KSC
Brent Bowen	Jim Aliberti	February 2003	KSC
Brent Bowen	Chuck Griffin	February 2003	KSC
Brent Bowen	Danny Culbertson	February 2003	KSC
Brent Bowen	Rita Willcoxon	February 2003	KSC
Richard Box	Phil Weber	February 2003	KSC
Richard Box	Gregg Buckingham	February 2003	KSC
Richard Box	Jim Aliberti	February 2003	KSC
Richard Box	Chuck Griffin	February 2003	KSC
Richard Box	Danny Culbertson	February 2003	KSC

Stennis Space Center (SSC)

Brent Bowen	Ramona Travis	NASA EPSCoR Meeting – Mar. 2003	Washington, DC
Brent Bowen	Ramona Travis	December 2002	SSC
Brent Bowen	Rodney McKellip	December 2002	SSC
Brent Bowen	Marco Gerodina	December 2002	SSC
Brent Bowen	Lloyd McGregor	December 2002	SSC
Brent Bowen	Bruce Davis	December 2002	SSC
Brent Bowen	Ronald Magee	December 2002	SSC
Brent Bowen	William Graham	December 2002	SSC
Karisa Vlasek	Ramona Travis	NASA Space Grant Mtg. – Oct. 2002	Dorado, PR
Karisa Vlasek	Ramona Travis	December 2002	SSC
Karisa Vlasek	Rodney McKellip	December 2002	SSC
Karisa Vlasek	Marco Gerodina	December 2002	SSC
Karisa Vlasek	Rodney McKellip	December 2003	GES telecon.
Karisa Vlasek	Lloyd McGregor	December 2002	SSC
Karisa Vlasek	Bruce Davis	December 2002	SSC
Karisa Vlasek	Ronald Magee	December 2002	SSC
Karisa Vlasek	William Graham	December 2002	SSC
Don Rundquist	Bruce Davis	March 2003	Denver, CO
Don Rundquist	Kirk Sharpe	Teleconference – April 2004	
Don Rundquist	James D. Huk	Proposal review request – April 2004	

Langley Research Center (LaRC)

Brent Bowen	Roger Hathaway	NASA EPSCoR Meeting – Mar. 2003	Washington, DC
Scott Tarry	Stuart Cooke	August 2002	LaRC
Scott Tarry	Bruce Holmes	August 2002	LaRC
Scott Tarry	Jerry Hefner	August 2002	LaRC
Scott Tarry	Elizabeth Ward	August 2002	LaRC
Scott Tarry	Jerry Hefner	TSAAWG – October 2003	LaRC
Scott Tarry	Stuart Cooke	TSAAWG – October 2003	LaRC
Scott Tarry	Bruce Holmes	March 2002	LaRC
Scott Tarry	Bruce Holmes	February 2004	LaRC
Massoum Moussavi	Jerry Hefner	TSAAWG – August 2002	LaRC

Massoum Moussavi	Bruce Holmes	TSAAWG – August 2002	LaRC
Massoum Moussavi	Stuart Cooke	TSAAWG – August 2002	LaRC
Massoum Moussavi	Pete McHugh	August 2002	LaRC
Massoum Moussavi	Elizabeth Ward	August 2002	LaRC
Massoum Moussavi	Roger Hathaway	August 2002	LaRC
Massoum Moussavi	Bryan Campbell	August 2002	LaRC
Karisa Vlasek	Stuart Cooke	March 2004	Chicago, IL
Karisa Vlasek	Roberto Sepulveda	October 2002	Dorado, PR
<i>Johnson Space Center (JSC)</i>			
Brent Bowen	Bonnie Dunbar	Western Region SG – September 2002	Big Sky, MT
Brent Bowen	Bonnie Dunbar	December 2002	JSC
Brent Bowen	Jennifer Blume	December 2002	JSC
Brent Bowen	Donald Henninger	December 2002	JSC
Brent Bowen	Kamlesh Lulla	December 2002	JSC
Brent Bowen	Brian Peacock	December 2002	JSC
Brent Bowen	Lakshmi Putcha	December 2002	JSC
Brent Bowen	Donn Sickorez	December 2002	JSC
Michaela Schaaf	Bonnie Dunbar	Western Region SG – September 2002	Big Sky, MT
Karisa Vlasek	Ota Lutz	October 2003	Pender, NE
<i>Glenn Flight Research Center (GRC)</i>			
Scott Tarry	Bob Corrigan	TSAAWG – October 2003	GRC
George Gogos	Vehda Nayagam	April 2002	Lincoln, NE
George Gogos	Vehda Nayagam	Fall 2002	Lincoln, NE
George Gogos	Vehda Nayagam	March 2003	Lincoln, NE
George Gogos	Vehda Nayagam	April 2003	Lincoln, NE
George Gogos	Vehda Nayagam	August 2003	Lincoln, NE
<i>Marshall Space Flight Center (MSFC)</i>			
Henry Lehrer	Dawn Mercer	January 2002	MSFC
Don Rundquist	Dale Quattrochi	Manuscript review request – July 2003	
NASA Headquarters			
Don Rundquist	Ed Sheffner	March 2003	Washington, DC
		Office of Earth Science Applications Division	
Henry Lehrer	John Barsa	March 2003	Washington, DC
Neal Grandgenett	Stacey Rudolph	periodic e-mail/phone contact	Arlington, VA
		Institute for Global Environmental Strategies	
Wallops			
Don Rundquist	Robert Swift	January 2004	Roatan Island
		Lidar Bathymetry Collaboration	

Attachment 3

Nebraska Geospatial Extension Program Research Outcomes

- Vlasek, K., Lehrer, H., Bowen, B., & Webb, C. (2004). *Utilizing geospatial technologies on Nebraska's Native American Reservations: A case study*. Omaha, NE: University of Nebraska Space Grant & EPSCoR.
- Vlasek, K., & Webb, C. (2004, August). *GIS at a tribal College: The Native IMAGE case study*. Paper to be presented at the 2004 Environmental Systems Research Institute Annual Education Users Conference, San Diego, CA.
- Vlasek, K. (2004, May). *Utilizing Hyperspectral remote sensing on the Winnebago Indian Reservation in Winnebago, NE*. [Abstract]. To be presented in the proceedings of the American Society for Photogrammetry and Remote Sensing, Denver, CO.
- Vlasek, K., & Webb, C. (2004, May). *Utilizing Hyperspectral remote sensing on the Winnebago Indian Reservation in Winnebago, Nebraska*. Poster to be presented at the 2004 ASPRS Conference, Denver, CO.
- Bowen, B., Vlasek, K., & Webb, C. (2004, April). *An assessment of remote sensing applications in transportation*. Paper to be presented at the Annual Academy of Sciences Annual Meeting, Lincoln, NE.
- Vlasek, K. (2004, April). The creation of the Nebraska geospatial extension program. To be presented at the 1st annual Geospatial Extension Specialists Meeting, Durham, NH.
- Vlasek, K., & Webb, C. (2004, April). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. Poster presented at the 124th Annual Nebraska Academy of Sciences, Lincoln, NE.
- Bowen, B., Vlasek, K., & Webb, C. (2004, March). *An assessment of remote sensing applications in transportation*. Paper presented at the 2004 Transportation Research Forum, Evanston, IL.
- Vlasek, K., & Webb, C. (2004, March). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. Poster to be presented at the 2004 Association of American Geographers Annual Meeting, Philadelphia, PA.
- Vlasek, K., & Webb, C. (2004, March). *Utilizing geospatial technologies on the Winnebago Indian Reservation*. [Abstract]. Proceedings of the Association of American Geographers Conference, Philadelphia, PA.
- Vlasek, K., Lehrer, H., Bowen, B., & Webb, C. (2003). *Utilizing geospatial technologies on Nebraska's Native American Reservations: A case study*. Omaha, NE: University of Nebraska Space Grant & EPSCoR.
- Vlasek, K. (2003, November). *The Nebraska geospatial extension program*. Poster presented at the Northeast Community GIS Day, Norfolk, NE.
- Vlasek, K. (2003, November). *Native IMAGE: (Institute for managing applications in geospatial extension): A Nebraska Geospatial Extension Initiative*. Poster presented at the Northeast Community GIS Day, Norfolk, NE.
- Vlasek, K. (2003, November). *The Nebraska geospatial extension program update*. Presented at the NASA Nebraska Space Grant & EPSCoR Technical Advisory Committee Meeting, Omaha, NE.
- Vlasek, K. (2003, October). *The Nebraska geospatial extension program: Program initiatives*. Presented at the On-Target Seminar, Salt Lake City, UT.
- Nickerson, J., & Vlasek, K. (2003, September). *Careers in aeronautics and the geosciences*. Native American Aviation and Aerospace Day, Wayne, NE.

- Vlasek, K. (2003, September). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Poster presentation at the 2003 Midwest ArcUsers Group Conference, Omaha, NE.
- Vlasek, K. (2003, September). *The Nebraska geospatial extension program: Working with Space Grant*. Presented at the Western Region Space Grant Meeting, Rapid City, SD.
- Vlasek, K. (2003, June). *Nebraska's geospatial extension program*. Paper presented at the Nebraska GIS/LIS Omaha User's Group Meeting, Omaha, NE.
- Vlasek, K. (2003, May). *Nebraska's geospatial program*. Paper presented at the 2003 Nebraska GIS Symposium, Lincoln, NE.
- Vlasek, K., Nickerson, J., & Schaaf, M. (2003, May). *Grant writing for the GIS professional*. Short course developed and delivered at the 2003 Nebraska GIS Symposium, Lincoln, NE.
- Lehrer, H., & Vlasek, K. (2003, April). *Native American geospatial outreach*. Paper presented at the University of Redlands and Environmental Research Systems Institute, Redlands, CA.
- Vlasek, K., & Lehrer, H. (2003, April). Native IMAGE (Institute for Managing Applications in Geospatial Extension) [Abstract]. *Proceedings of the 123rd Nebraska Academy of Sciences*, 33.
- Vlasek, K., & Lehrer, H. (2003, April). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Poster presented at the 123rd Annual Meeting of the Nebraska Academy of Sciences, Lincoln, NE.
- Bowen, B., Lehrer, H., Brown, S., Nickerson, J., & Vlasek, K. (2003, March). *Native IMAGE (Institute for Managing Applications in Geospatial Extension): A Nebraska geospatial extension initiative*. Paper presented at the NASA EPSCoR Director's Meeting, Washington, D.C.
- Bowen, B., Vlasek, K., & Webb, C. (2003, March). *An assessment of remote sensing applications in transportation*. Paper presented at the 2004 Transportation Research Forum, Evanston, IL.
- Trimm, J., Vlasek, K., & Bowen, B. (2002). *Existing geospatial programs at American Indian colleges*. Omaha, NE: University of Nebraska at Omaha Aviation Institute.
- Vlasek, K., Bowen, B., & Schaaf, M. (2002, December). *Nebraska's geospatial extension program*. Paper presented at the NASA Nebraska Space Grant and EPSCoR Technical Advisory Committee Meeting, Lincoln, NE.
- Lehrer, H., & Vlasek, K. (2002, October). *Santee Sioux geospatial demonstration project*. Project presented at Santee Geospatial Science Night, Santee, NE.
- Vlasek, K. (2002, October). *Integrating science and Native American culture*. Poster presentation at the National Council of Space Grant Directors Fall Meeting, Dorado, Puerto Rico.
- Vlasek, K., Bowen, B., & Schaaf, M. (2002, October). *Nebraska's geospatial extension program*. Paper presented at the National Council of Space Grant Directors Fall Meeting, Dorado, Puerto Rico.
- Lehrer, H., Vlasek, K., Nickerson, J., & Bowen, B. (2002, October). *Geoscience education opportunities on the Winnebago Indian reservation (GEOWIRE)*. Proposal to NSF, \$900,000. Not Funded.
- Lehrer, H., Nickerson, J., & Vlasek, K. (2002, October). *Santee Sioux Family Geospatial Science Night*. Workshop developed and delivered on the Santee Sioux Reservation, Santee, NE.

Aeronautics Education, Research, and Industry Alliance (AERIAL) Request for Continuation in Years 4 and 5

1. Two Year Program Plan and Budget

Program Administration

The administration of AERIAL during Years 4 and 5 will continue to focus on achieving the program's goals and objectives, including ongoing identification of collaborative opportunities with NASA personnel, supporting AERIAL's research endeavors, building Nebraska's aerospace infrastructure facility technology transfer, developing outreach activities, and enhancing inclusion of Native Americans in all program activities. The AERIAL Strategic Plan, routinely reviewed by the TAC, will continue to direct program activities, ensuring advancement of NASA interests.

Coordination with Nebraska Space Grant Consortium (NSGC)

As director of the NSGC, Dr. Bowen will continue to ensure that all written and oral AERIAL progress reports are offered to the NSGC advisory board through meetings or individual consultation. Through external review, NSGC board members will provide comments and recommendations regarding AERIAL activities, progress, and modifications. This will be completed during the annual AERIAL performance review. Dr. Bowen's dual role as NSGC director and AERIAL director will continue to ensure effective and efficient coordination and communication between the two organizations. For example, proposed AERIAL initiatives regarding geospatial extension, Native American outreach, and workforce development will continue to complement the objectives of the NSGC during Years 4 and 5.

Coordination with State EPSCoR Committee and Other Stakeholder Organizations

The AERIAL leadership team recognizes the importance of coordinating its efforts with the Nebraska EPSCoR office. Therefore, in Years 4 and 5, Project Director Bowen will continue to provide regular AERIAL progress reports to the Nebraska EPSCoR Committee, working synergistically with this agency. Additionally, members of the EPSCoR committee will be asked to participate in annual external reviews of the CRTs' performance and outcomes. Coordination with the Nebraska EPSCoR office is also maintained through the AERIAL Communications Specialist, who contributes AERIAL updates to the state EPSCoR newsletters, brochures, and presentation displays. AERIAL will coordinate its activities with those of Nebraska EPSCoR and other federal agencies, including the DOD, NSF, FAA, and Department of Transportation. All organizations affiliated with AERIAL, including federal agencies, will continue to be actively encouraged to utilize the NASA Nebraska AERIAL website and e-mail distribution lists regarding AERIAL announcements.

Funds Distribution and Financial Management Systems and Controls

As with the CRTs, all fund distributions will be made on a competitive basis. Calls for proposals will continue to be issued statewide through a variety of channels, and proposals will be accepted from faculty members at any Nebraska institution. Selection will be made by ad-hoc committees drawn from the AERIAL TAC, the Nebraska EPSCoR Advisory Board, and the NSGC.

During Years 4 and 5, the UNO Aviation Institute will continue to house and act as the managing structure for AERIAL, and thus maintain overall control and responsibility for its implementation. All participating AERIAL institutions will continue to form subcontractual agreements with UNO. These agreements will use standard grants, contracts, and financial accounting procedures, which are subject to internal and external audits. Dr. Bowen will be responsible for day-to-day fiscal management of AERIAL, while UNO's Office of Grants

Accounting will prepare regular fiscal reports. Dr. Bowen will review and approve appropriate project expenditures, subject to further approval and review as specified in university procedures.

Support for NASA Collaboration Building

Travel Grants

As proven effective in the past, AERIAL will utilize continued NASA EPSCoR funds to provide travel grants to faculty and staff for collaboration-building at NASA research and field centers. AERIAL will continue to give priority to faculty members who are not members of the three CRTs but who wish to pursue new NASA collaborations. Based on NASA Nebraska EPSCoR's past experience, several types of travel grants will continue to be available, including those for: (a) day visits; (b) short-term (three to four days) visits; (c) one- to two-week visits; and (d) 10-week faculty internships. Travel grants will continue to be awarded to faculty members for travel to other academic institutions for establishing NASA collaboration. AERIAL will continue to award travel grants for faculty researchers to attend academic conferences, symposia, and/or technical meetings that offer opportunities for the development of new networks and linkages with NASA-affiliated researchers as well as joint presentations and the strengthening of existing collaborations. Current travel grants have fostered collaborative relationships at **all NASA Centers** and NASA Headquarters. A comprehensive list of Nebraska's NASA Center collaborations is shown in Attachment 2.

Schedule of Joint Meetings with NASA Personnel

A key component of Nebraska's strategy in initiating, broadening, and sustaining its relationships with NASA personnel will continue into Years 4 and 5 with emphasis on face-to-face, on-site meetings with personnel from NASA Field Centers and Strategic Enterprise Offices at NASA Headquarters. NASA Nebraska/AERIAL Director Bowen, with assistance from AERIAL staff, will continue this strategy by meeting at least once each year with NASA EPSCoR personnel at NASA Headquarters and University Affairs Officers at collaborating NASA Field Centers. AERIAL CRT personnel will continue to visit their identified collaborating Field Centers on at least an annual basis. Additional meetings will be scheduled at academic conferences or symposia when Nebraska and respective NASA collaborators are in attendance. NASA researchers will continue to be invited to Nebraska for meetings with AERIAL administrators and/or CRT faculty researchers and students. A comprehensive list of Nebraska's NASA Center collaboration since 2001 is shown in Attachment 2.

Electronic Resources

The NASA Nebraska EPSCoR/AERIAL management team will continue to utilize extensive electronic resources to bolster AERIAL's research and outreach endeavors, further the goals of AERIAL, and extend its impact throughout the state and nation. During Years 4 and 5, the existing NSGC & EPSCoR website (<http://nasa.unomaha.edu>) will be expanded in the continued development of AERIAL, including grant announcements and applications, research projects, program descriptions, program staff, and upcoming events. The website currently provides links to: (a) NASA, NASA EPSCoR, NASA Enterprises and Centers, and the National Space Grant and Fellowship programs; (b) numerous aerospace/aeronautics websites; and (c) other NASA EPSCoR and Space Grant-funded sites.

Nebraska will continue to develop CD-ROMs for classroom enhancement material and document delivery. Nebraska will continue to utilize e-learning technologies by enhancing and developing the Aviation Institute's on-line degree program, CD-ROM production, Aviation Institute Flight Lab resources, and faculty/staff productivity support. A collaborative effort will continue to be maintained with the University of Nebraska at Kearney to provide on-line courses

that students need for graduation. NSGC & EPSCoR will also continue to provide funding for the management of a computer lab and resource center for students within its college. The lab houses 20 computers and three staff members, while the resource center offers student lounge meeting facilities.

Technology Transfer/Industrial Relations

NASA Nebraska EPSCoR will be committed to the identification and development of technology transfer opportunities. The technology transfer phase of the research project transforms the designs, ideas, research, and innovations of Nebraska researchers to the development phase, where the project is nurtured by identified technology transfer experts (eventually leading to utilization applications). The team collaborates with many organizations and individuals to stimulate technology transfer. During Year 3, the team identified individuals at each NASA Center whose expertise will be utilized in Years 4 and 5. Mr. Al Wenstrand, Director of the Nebraska Department of Economic Development, will continue to serve on the AERIAL TAC, and Mr. Stephen Frayser, President of the University of Nebraska Technology Park will continue to provide guidance in this area.

During Year 3, NASA Nebraska EPSCoR's partnerships with CALMIT provided opportunities to work with the Nebraska extension service, and specifically to work with CALMIT's commercial program. This collaboration will continue in Years 4 and 5. Each of the AERIAL CRTs will continue their technology transfer plans. Private industry collaborators will continue to be invited to participate in the advisory board meetings, where they can provide guidance and input for the program's research activities.

Public Outreach Education and Extension

Outreach education and extension play a fundamental role in the AERIAL EPSCoR grant, focusing on three areas: (a) the use of the World Wide Web to post information; (b) collaboration through regional and national conferences in aeronautics and education; and (c) the enhancement of distance education capabilities and technologies. These cornerstone projects will continue to be associated with AERIAL's outreach education and extension efforts. Each component – based on the research of the CRTs – encompasses collaboration with researchers and NASA personnel, while working with extension agencies, disseminating information, and partnering with Native IMAGE. The AERIAL team will continue to support the educational outreach activities of the NSGC & EPSCoR programs through project management and external communications. The liaison function of this position will continue to promote and strengthen the relationship between the NSGC & EPSCoR office and the community. The Geospatial Extension and Research Specialist (GES) will work closely with Native IMAGE personnel to enhance and expand upon the geospatial data that was incorporated into the Family Aeronautical Science program during Year 3. The GES will also continue to seek new opportunities for geospatial outreach.

Student Support/Workforce Development

Nebraska's ability to sustain long-term growth in aeronautics research and industry depends upon the ongoing development of a well-trained aerospace workforce. Nebraska will continue enhancing its internal capacity to motivate its youth to pursue education and careers in aerospace-related fields and encourage them to seek related employment in the state. NSGC continues to be the primary source of aerospace-related outreach activities for Nebraska. However, during Years 4 and 5, AERIAL will continue to provide CRT-based outreach activities, fellowships, assistantships, and internships for undergraduate and graduate students.

The Geospatial Extension and Implementation teams will continue to support the workforce development components of the program.

Nebraska Geospatial Extension Program

The Nebraska Geospatial Extension Program (NEGEP) has fulfilled NASA's goal of the placing a Geospatial Extension Specialist (GES) in the state. However, Nebraska is currently one of only eleven states to develop such a program. Therefore, there is substantial opportunity for increased collaborations in the field of geosciences. Karisa Vlasek, Nebraska's GES, has established numerous nationwide partnerships and will continue to serve in this role for 2004-2006. NEGEP will continue to serve Nebraska's citizens in the area of geospatial technologies. The following activities will be pursued by NEGEP during Years 4 and 5:

Further Development of Native IMAGE

NEGEP will continue to support the expansion of Native IMAGE through collaborative activities, including, but not limited to: (1) training workshops in geospatial technologies, (2) library and laboratory enhancements, (2) student assistantship opportunities, (3) community development, (4) outreach projects, and (5) development of geospatial data centers.

Establishment of Geospatial Data Centers

A priority component of NEGEP is the development and placement of geospatial data centers across Nebraska. The first data center was placed within Native IMAGE in 2003. Students from LPTC, as well as Winnebago community members, now have access to hardware, geospatial software, and GIS and remote sensing technologies. Another data center was implemented at Nebraska Indian Community College in 2003 in Santee, Nebraska. The development and implementation of other data centers at community and tribal colleges across Nebraska will continue to be pursued during Years 4 and 5.

CRT Collaborations

Collaborations between the ARS CRT and NEGEP will continue to be fostered. The ARS platform provides an opportunity for data collection using a true color and color infrared camera, ASD (spectral radiometer), and the AISA (airborne imaging spectrometer) sensor. Data collection took place using the color infrared camera over the Santee Sioux and Winnebago Reservation in 2002. Additional missions are planned for further reservation data collection.

NEGEP will also continue its development of a stronger partnership with the SATS CRT. Several areas of the SATS project have been identified for collaboration during 2004. The SATS team has been working on their capability to engage in noise modeling. GIS is a powerful tool that can be used to overlay, store, and analyze noise contours. By partnering together, the SATS CRT can utilize many of NEGEP's geospatial tools including GIS and remote sensing.

GeoSTAC (GeoSpatial Training and Analysis Cooperative)

NEGEP's relationship with the Idaho Space Grant Consortium & EPSCoR Program will continue to be cultivated in Years 4 and 5. GeoSTAC, a product of Idaho Space Grant, was developed to offer on-line, non-credit tutorials in geospatial technologies. The primary goals of GeoSTAC include (1) training the future workforce; (2) providing a link between university, government, and private industry with geospatial technologies; (3) promoting the end use of NASA and other remote sensing platforms; and (4) providing tools for decision-making. On-line training will continue to be a key component of NEGEP's Workforce Development Initiative and Native IMAGE.

Lewis and Clark Collaborations

The 2003 collaboration between NEGEP and the Bicentennial commemoration of the Lewis and Clark Expedition will result in numerous activities. These activities will take place

across Nebraska in 2004. Geospatial technologies will enhance understanding of the expedition. Native IMAGE will give Native Americans the opportunity to describe how the Lewis and Clark Expedition impacted the course of their history.

Outreach Collaborations

During Year 3, a successful relationship was established with UNO's College of Education, which involved development of the DataSlate CD-ROM and the International Space Station EarthKAM Project. NEGEP will maintain support for DataSlate dissemination and will participate in further development of CD content. These activities are part of NEGEP's goal to engage the K-16 community in geospatial education. New collaborations for K-16 education will be identified, pursued, and developed for 2004-2006.

University of Nebraska Cooperative Extension

The partnership that was established in 2003 with the University of Nebraska Cooperative Extension will be cultivated in 2004. This includes the development of geospatial workshops and seminars for Cooperative Extension Agents, who can then train potential users such as farmers and ranchers.

Opportunities for Presentations and Publications

Numerous opportunities in Years 4 and 5 have already been identified and will continue to be developed for members of NEGEP to present and publish their research. Specifically, Nebraska will submit various outcomes for presentation at the Soil and Water Conservation Society Annual Conference in St. Paul, MN in July 2004. These submissions will include: (1) a panel discussion focused on remote sensing applications in conservation, established through collaboration between Nebraska, Ohio, North Dakota, and Arizona; and (2) a poster submission for all eleven GES states, highlighting the national program. NEGEP plans to host a gathering of all Geospatial Extension Specialists at the NASA Western Region Meeting in September 2004. A similar format to the National GES Conference will be followed with round-table discussions and exchange of best practices.

Grant Writing for the GIS Professional

AERIAL conducted a workshop titled "Grant Writing for the GIS Professional," in May 2003 at the Nebraska GIS Symposium in Lincoln, NE. Due to the overwhelming positive response received from this workshop, another GIS grant-writing workshop is planned for the Symposium in 2005.

Certificate Development

As part of NASA's workforce development initiative, in Years 4 and 5 NEGEP will develop a non-credit certificate program in partnership with CALMIT. This will be the only program in Nebraska to offer a non-credit certificate in geospatial technologies. Organizations in Nebraska need a place for their employees to obtain geospatial training. Currently, few places offer non-credit training in remote sensing. Remote sensing training is only offered at Nebraska's Universities for credit. The proposed non-credit certificate in geospatial technologies will offer Nebraska residents an opportunity to develop or enhance skills and contribute to a stronger workforce. Native IMAGE is also developing a certificate program, which will focus on geospatial technologies with a Native American focus.

Native Institute for Managing Applications of Geospatial Extension (Native IMAGE)

Dr. Henry R. Lehrer, with assistance from Ms. Jan Bingen, continues to lead Native IMAGE. Ms. Bingen, LPTC Computer Science Department Director, has increased her involvement in Native IMAGE, which now includes education and public outreach

responsibilities. During Years 4 and 5, other LPTC faculty, staff, and consultant trainers will offer their support for completion of the following Native IMAGE objectives:

Training and Faculty Development

With assistance from NEGEP, Native IMAGE will continue to provide GIS and remote sensing training and research opportunities in the other geospatial fields. During Years 4 and 5, Native IMAGE personnel will continue to organize geospatial workshops and coordinate enhancement of LPTC's traditional and on-line courses. Such workshops during 2003 allowed LPTC, CALMIT, and UNO to share collected data with the Winnebago community through articles, posters, presentations, and geospatial training modules. Native IMAGE will also continue to provide training in geospatial subjects for faculty at LPTC and WPS. Workshop opportunities will be available during the summer at the USGS EROS Data Center and CALMIT. As proven effective during 2003, workshops in Years 4 and 5 will continue to expose Nebraska faculty to in-depth training in GIS, remotes sensing, and GPS.

Opportunities for Students

Native IMAGE will continue to offer LPTC students opportunities for assistantships, which have proven effective thus far, with two student assistantships already fostered through the Institute. In addition, a geosciences club, developed during 2003, will continue to be open to interested students in the Winnebago area. The club will continue to focus on educational activities, field trips, guest speakers, and educational and career opportunities in the geosciences.

Development of Library Materials

In partnership with the NEGEP, Native IMAGE will continue the procurement of geospatial holdings for the expansion of the LPTC/Winnebago Library. With the placement of a geospatial lab at LPTC, these materials are an invaluable resource.

Creating Community Partnerships

During 2003, Native IMAGE assisted LPTC and the Winnebago community in collecting geospatial information. In Years 4 and 5, this data will be used to locate and identify the location of significant tribal cultural resources and historical sites. David Smith, Winnebago Tribal Historian and Archivist, will continue collaborating with Native IMAGE personnel to locate and catalogue former tribal burial sites.

Fostering Collaborations

Of the 35 current tribal colleges, few are engaging in a geospatial emphasis. Native IMAGE has fostered collaboration between the Winnebago community, LPTC, and faculty participants from other tribal colleges including NICC, Salish Kootenai College, and Sinte Gleska University, among others. Native IMAGE personnel will continue to actively support NativeView, a data archiving endeavor housed at the Sinte Gleska College in Rosebud, SD. The Institute will continue to establish outreach relationships with other tribes and tribal colleges.

Geospatial Station

The development of an innovative geospatial laboratory at LPTC was achieved in 2003. Through this lab, the Winnebago community now has access to a variety of GIS and remote sensing software, hardware, and equipment. During Years 4 and 5, Native IMAGE personnel will develop this geospatial station to ensure that the Winnebago community continues to have access to current and advanced technologies.

Establishment of a Native IMAGE Advisory Board

Native IMAGE personnel have established an advisory committee, which consists of individuals from academics (Creighton, UNO, UNL-CALMIT, Wayne State), industry (ESRI), government (tribal council, EROS Data Center), and other tribal colleges (Sinte Gleska, Salish

Kootenai, Diné). The membership of this board will continue to be enhanced and cultivated during 2005 and 2006.

Nebraska Native American Outreach Program (NNAOP)

Development of strong linkages and a viable partnership with the Winnebago Public Schools (WPS) have been and will continue to be a high priority in Years 4 and 5. Specifically, the NNAOP will continue to inspire Native American youth from Nebraska to pursue academic and professional careers in the aeronautics and aerospace fields. The expansion of the highly successful Family Aeronautical Science (FAS) program will continue to be a priority for the AERIAL team. FAS activities were enhanced in Year 3 through the integration of geospatial-related activities into the program curriculum. This new curriculum, known as Family Geoscience (FGS) includes topics such as GPS, GIS, and remote sensing. In Years 4 and 5, FAS and FGS will continue to include evening meals combined with science demonstrations, directed group activities, visits by NASA researchers/educators, and fellowship. The underlying goal continues to be the improvement of mathematics and science skills among these Native American youngsters through involvement of the family unit.

In continuing AERIAL's mission to administer its programs and opportunities to underrepresented groups, Native IMAGE will continue to support participating FAS teachers with small faculty stipends. The UNO Aviation Institute will continue to provide FAS supplies and meal expenses. In the upcoming years, Native IMAGE personnel will facilitate the exportation of the FGS curriculum to Walthill and Santee Public Schools.

2. Metrics for Tracking and Evaluating Program Progress

Technical Advisory Committee (TAC)

In continuing AERIAL's effective advisory board schedule of meetings, the TAC will convene semi-annually during Years 4 and 5 (December 2004, April 2005, December 2005, and April 2006) to provide evaluative advice and recommendations to the AERIAL leadership team. Members will be informed of progress through reports and presentations from Dr. Bowen and CRT principal investigators as well as evaluation results and statements. The TAC will continue to participate in AERIAL's strategic planning process through in-depth interviews, board meetings, and review of draft documents; its members will act as liaisons between AERIAL and the organizations they represent. For a complete listing of current TAC Members, please see "Report of Progress". To ensure the same high level of integrity seen in Years 1-3, the TAC will continue to be composed of personnel from Nebraska industry, Nebraska government, Nebraska Space Grant, Nebraska EPSCoR, and other influential members of the aviation community and academia. They bring to the board ample resources and knowledge to advance the goals of AERIAL. TAC configuration is designed to ensure that productive relationships between AERIAL and Nebraska's programs are cultivated and sustained.

Quality Assurance and Program Evaluation Planning

The NASA Nebraska EPSCoR management team will continue to use its data management system in the implementation of its NASA-funded projects. Intensive self- and external evaluations will continue to occur for all AERIAL components. Consistent with NASA EPSCoR guidelines, the primary components of the evaluation will be: (a) research success of each AERIAL CRT; (b) examples of technology transfer occurring due to AERIAL-sponsored research; (c) evidence of evolving collaboration among AERIAL staff and researchers and researchers from NASA Field Centers and/or the Strategic Enterprise Offices at NASA Headquarters; (d) evidence of new, collaborative aerospace research activities occurring within

the state; and (e) indications of how AERIAL activities have addressed state priorities in technology, aerospace/aviation, and economic development. All program evaluations and reports will be reviewed by Dr. Bowen and the Nebraska Space Grant Consortium Board. Additionally, program research and outreach initiatives will be examined at the planned biannual AERIAL TAC meetings. Recommendations for ensuing years will be recorded, and modifications will be made as necessary. Dr. Bowen will continue to submit annual reports to NASA University Affairs for evaluation.

CRT principal investigators will continue to provide evidence of scientific accomplishment and demonstrate communication of those accomplishments through: (a) scientific publications and/or presentations at academic conferences and/or symposia; (b) increased collaboration with NASA and other researchers in Nebraska; (c) contributions to industry; (d) patents; (e) proposal submissions to other funding sources; and (f) improvements in infrastructure. Evaluations will focus on these outcomes and are considered prior to future awards. Additionally, all recipients of fellowships and seed and travel grants will submit reports detailing scientific accomplishments.

AERIAL's success will be measured by indicators of long-term systemic growth in Nebraska's aerospace research capacity and industrial development that will be evident long after NASA funding ceases. Progress toward this end will be measured in several ways during and after the funding period of AERIAL: (a) in the increased level of aerospace research activities throughout the state (as evidenced through increased levels of refereed publications, invited presentations, development of patents, etc); (b) in the increase in non-NASA forms of aerospace research funding by senior and junior faculty members; (c) by the development of new (and expansion of current) aerospace-related industry that leads to overall growth in the state's economy; (d) in a net increase of Nebraskan students enrolling in aerospace-related fields of study at Nebraska's colleges and universities as well as an increase in the number of Nebraskan college graduates accepting faculty and research positions within the state; and (e) in the increased level of NASA-driven collaborative research throughout the state.

Completion of AERIAL Objectives

AERIAL's originally proposed objectives have directed successful activities and innovative research since 2001. If funded, AERIAL researchers will continue the objectives that were originally proposed. Successful completion of the activities within this proposal and timetable (below) will signify fulfillment of the objectives, which are to:

- I. Increase the level and extent of productive collaborations between Nebraska researchers and NASA personnel, leading to cooperative scientific inquiry that contributes to NASA's strategic research and technology priorities.
- II. Support the activities of three high-profile collaborative research teams that (a) directly relate to the NASA mission, (b) align with priorities and research needs of NASA's Strategic Enterprises and Centers, and (c) simultaneously have realistic and positive implications for the development of related industry and overall economic development in Nebraska. These research activities will have a sufficiently high impact, profile, and likelihood of success to act as catalysts for broadened academic inquiry, expanded industrial development, and heightened public interest in aeronautical science.
- III. Raise the aggregate quality and quantity of Nebraska's aeronautics research endeavors to the highest level of national competitiveness through financial support, infrastructure development, and facilitation of networks and collaboration.

- IV. Further expand the supportive, cooperative, and dynamic aerospace research environment within the state that will foster the development of junior faculty members into nationally competitive and recognized researchers.
- V. Ensure effective technology transfer of AERIAL research endeavors to Nebraska industry through ongoing program participation by key industrial and state leaders as well as effective implementation strategies.
- VI. Contribute to the state's aerospace workforce development by motivating talented Nebraska youth, and in particular those from underrepresented populations, to pursue post-secondary and graduate-level education and careers in aerospace science and industry through the development of intriguing research-related public outreach activities and assistantships.
- VII. Continue ongoing strategic vision and planning activities that focus on increasing the state's capacity to compete successfully for research and development funding from sources other than EPSCoR.

3. Milestones and Timetable for Achieving Objectives

The following timetables provide anticipated research outcomes for Years 4 and 5. Completion of these activities would signify achievement of the above AERIAL objectives. However, AERIAL personnel will not be limited to these activities, as faculty and staff continually pursue new and innovative activities as opportunities to do so arise. Activities are categorized by specific AERIAL objectives. AERIAL milestones for Years 4 and 5 are indicated in red lettering.

Year 4

<u>Activity to Accomplish Objective</u>	<u>AERIAL Objective</u>	<u>Expected Completion</u>
CRTs submit quarterly reports	II	October 2004
Plan and execute fall TAC meeting	I, V, VII	December 2004
CRTs submit quarterly reports	II	January 2005
Plan for seed research selections	III, IV	January 2005
Seed research awarded through competitive statewide selection	III, IV	February 2005
Submit Annual Report to NASA	I, II	April 2005
Maintaining CRT white papers and websites	II	Monthly, as necessary
Maintain CD-ROM updates and production	I, III, IV, V	Monthly, as necessary
Monograph publication	I, III, IV, V	Three times annually
Plan and execute spring TAC meeting	I, V, VII	April 2005
Planning/Participation in Annual Nebraska Academy of Sciences	I, III, IV, V	April 2005
Planning/Executing 2005 NSGC & EPSCoR Statewide Scholarship Competition	VI	April 2005
CRTs submit quarterly reports	II	July 2005
Hosting Native American Outreach events	VI	Three times annually
Providing support and planning to Native IMAGE/LPTC	I, III, V, VI, VII	Three times annually
CRT contact with Technical Monitor	II	Three times annually
CRT Principal Investigator (or designated representative) to visit NASA Centers	I, II	One time annually
CRT Principal Investigator to hold team assessment and directive meetings	II	Three times annually
CRT Leaders to present research at national and/or regional conferences and/or meetings	I, II, III	Two times annually
AERIAL personnel to present research at national and/or regional conference and/or meetings	I, III	Two times annually
Travel grants awarded to faculty, staff, and students for collaboration building activities both NASA and non-NASA functions	I, III	Monthly, as necessary
Plan/Execute transfer scholarship, career presentations, and workshops for students from Nebraska's Native American schools	VI	Three times annually
Pursue non-NASA funding for expansion for AERIAL activities	VII	Continually

Year 5

<u>Activity to Accomplish Objective</u>	<u>AERIAL Objective</u>	<u>Expected Completion</u>
CRTs submit quarterly reports	II	October 2005
Plan and execute fall TAC meeting	I, V, VII	December 2005
CRTs submit quarterly reports	II	January 2006
Plan for seed research selections	III, IV	January 2006
Seed research awarded through competitive statewide selection	III, IV	February 2006
Submit Annual Report to NASA	I, II	April 2006
Maintaining CRT white papers and websites	II	Monthly, as necessary
Maintain CD-ROM updates and production	I, III, IV, V	Monthly, as necessary
Monograph publication	I, III, IV, V	Three times annually
Plan and execute spring TAC meeting	I, V, VII	April 2006
Planning/Participation in Annual Nebraska Academy of Sciences	I, III, IV, V	April 2006
Planning/Executing 2005 NSGC & EPSCoR Statewide Scholarship Competition	VI	April 2006
Hosting Native American Outreach events	VI	Three times annually
Providing support and planning to Native IMAGE/LPTC	I, III, V, VI, VII	Three times annually
CRT contact with Technical Monitor	II	Three times annually
CRT Principal Investigator (or designated representative) to visit NASA Centers	I, II	One time annually
CRT Principal Investigator to hold team assessment and directive meetings	II	Three times annually
CRT Leaders to present research at national and/or regional conferences and/or meetings	I, II, III	Two times annually
AERIAL personnel to present research at national and/or regional conference and/or meetings	I, III	Two times annually
Travel grants awarded to faculty, staff, and students for collaboration building activities both NASA and non-NASA functions	I, III	Monthly, as necessary
Plan/Execute transfer scholarship, career presentations, and workshops for students from Nebraska's Native American schools	VI	Three times annually
Pursue non-NASA funding for expansion for AERIAL activities	VII	Continually

NASA NEBRASKA EPSCOR
AIRBORNE REMOTE SENSING (ARS)

Dr. Don Rundquist, PI
University of Nebraska – Lincoln
Center for Advanced Land Management Information Technologies
113 Nebraska Hall
Lincoln, NE 68522

(402) 472-7536 phone
(402) 472-2408 fax
drundquist1@unl.edu

Cooperative Agreement #: NCC5-572

Submitted: April 30, 2004

Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Report of Progress for the

**Airborne Remote Sensing for Agricultural Research and Commercialization Applications
(ARS) Collaborative Research Team**

I. Original Proposal Abstract

The major objective of the proposed research of this collaborative research team (CRT) is to enhance the ways in which airborne remote sensing technology can be exploited for agricultural applications through the development and testing of novel sensors and algorithms. Tremendous advances in remote sensing technology and computing power over the last few decades are now providing scientists with the opportunity to investigate, measure, and model environmental patterns and processes with increasing confidence. Airborne remote sensing is critical for studying the evolution of rapid environmental patterns and processes over time scales of a few hours to days and over large spatial scales covering hundreds of square kilometers.

A recent National Science Foundation (NSF) grant provides for the purchase, air-frame modification, and initial operation and maintenance of an aerial platform to be used for the specific purpose of remote sensing research. The single-engine Piper Saratoga aircraft, purchased in October 2000, is currently undergoing air-frame modification for mounting of remote sensing instrumentation. We expect the aircraft to be fully operational for remote sensing research in March 2001. Our current proposal is aimed at further enhancing the NSF award by adding state-of-the-art equipment to the airplane, thereby supplementing our existing well-known and significant capabilities in remote sensing. The primary focus for the research (both basic and applied) is remote sensing of crop-land agriculture as well as pasture/grassland. A key element in the future development of precision agriculture is the incorporation of remotely sensed data into prediction algorithms (e.g., estimation of final yield), which can then be made available to economic decision-makers. The proposed project builds on high priority initiatives of the University, colleges, and departments and adds to the infrastructure created through prior NASA funding. This facility is also expected to foster close interaction between the university and industry as well as government agencies nationwide.

This proposal addresses NASA's priority initiatives in agriculture, with links to: (a) the NASA-Affiliated Research Center at UNL (funded by NASA Stennis Space Center) for commercialization applications; and (b) the NASA-funded America's Farm activity (funded by NASA Ames and GSFC) for remote sensing education as it applies to agriculture. The proposal also ties in well with NASA's mission in aeronautics and specifically with the Earth and Space Science (ESS) project, which aims to increase the capability to produce, analyze, and understand science and mission data as well as to develop a suite of simulations and data products. Among NASA's topics of relevance related to its Aeronautics mission is the increasing use and application of low-cost on-demand remote sensing capabilities, which suggest the development of improved remote sensing systems operating from airborne platforms. **Our proposal also addresses various research priorities of the Strategic Enterprises and Research Centers as enumerated in the NASA EPSCoR Compendium, primarily ESE21 (Agriculture).**

The University of Nebraska contingent of internationally-known scientists -- spanning the disciplines of computer science, engineering, remote sensing/GIS, geography, and agronomy -- is particularly well-prepared to make significant advances in the science and engineering of airborne remote sensing systems. Our vision for the proposed work is to focus our expertise and

experience on the technologies of remote sensing, geographic information systems, global positioning systems, real-time aircraft-data reception, and field measurement in agriculture. Although our primary focus is to conduct basic research, we also propose to emphasize practical applications that should be linked with private enterprise. In addition, outreach offerings (such as collaboration with cooperative extension) and technology transfer objectives, as well as the mentoring of junior faculty members and graduate students in the area of remote sensing, will be addressed.

II. Team Accomplishments

The ARS CRT is a resounding success in terms of meeting original objectives. The first goal was to have an operational airborne remote sensing platform by 2001. This was accomplished with the modifications to the airframe and the installation of the "AISA," a modern, unique hyperspectral imager. Thus, we enhanced the original NSF award (for purchase of the aircraft) by installing and operating a state-of-the-art sensor. Being able to operate the AISA as and when needed provides a very important infrastructure element to the ARS CRT; and it is a powerful partner with the outstanding field data-collection program operated by the UNL Center for Advanced Land Management Information Technologies (CALMIT). The rapid turn-around time between flying an AISA mission and being able to begin processing data is a very important benefit regarding our operating our own aircraft and sensor systems. Another important benefit is the ability to fly the sensor at the spatial and spectral resolutions needed for a particular project. The successes documented because of our capability to fly the AISA contributed to achieving our overall goal of enhancing the ways airborne remote sensing can be used for agricultural applications. The large, on-going projects (discussed below) at the University of Nebraska Agricultural Research and Development Center (ARDC) provide evidence of our successes. Those achievements have attracted the attention of other UNL researchers and have led to our proposing several new activities (see proposal section, below). New spectral indices, developed by one of our CALMIT colleagues (Professor Gitelson) have, in turn, led to novel processing algorithms for applying to airborne AISA data in agriculture. Although missions have been flown for assessing various natural-resources issues (e.g., water quality), we have maintained our original focus on agriculture. The collaborations that have been developed between the university and both private (e.g., Spectrum Mapping, Inc.) and public agencies (e.g., USDA) have been nothing short of remarkable. The Piper Saratoga and the AISA have facilitated collaboration with many new groups.

The other elements of the ARS CRT have also made important advances with regard to Nebraska's remote-sensing capabilities. The Lidar group, led formerly by Dr. Ram Narayanan, refurbished a NASA instrument, tested the system, and now stands ready to install and test that sensor using the Piper Saratoga platform. We are now taking steps to partner with South Dakota State University in moving the Lidar program forward. Similarly, the Laser group, under Dr. Dennis Alexander's leadership, has done laboratory testing aimed at studying the fluorescence characteristics of photosynthetic materials. Their successes point to a need to move those sensors to the aircraft platform, which we plan to attempt in the next two years. Finally, Dr. Palmer's group has modeled backscatter of synthetic aperture radar (SAR) returns to simulate data collection from our airborne platform, an important need as we strive to eventually operate an airborne SAR system.

The ARS CRT has experienced high levels of research success as it moves toward completion of its third year of AERIAL funding. Such success is evident in the

comprehensiveness of the various outcomes that have resulted from the ARS team's work. This progress is documented in Attachment 4.

III. ARS Articles Submitted to and/or Published in Refereed Journals

1. Tan, S., & Narayanan, R., (in press). Design and performance of a multiwavelength airborne polarimetric lidar for vegetation remote sensing. *Applied Optics*.
2. Pan, G., & Narayanan, R. (in press). Electromagnetic scattering from a dielectric sheet using the method of moments with approximate boundary condition. *Electromagnetics*.
3. Deshpande, D., Malshe, A., Stach, E., Radmilovic, V., Alexander, D., Doerr, D., & D. Hirt. (in review). Morphological, spectroscopic and microstructural analysis of femtosecond laser processed lithium niobate. *Journal of Applied Physics*.
4. Li, L., Lu, Y., Doerr, D., Alexander, D., Shi, J., & J. Li. (2004). Fabrication of hemispherical cavity arrays on silicon substrates using laser-assisted nanoimprinting of self-assembled particles. *Nanotechnology*, 15(3), 333-336.
5. Li, L., Lu, Y., Doerr, D., Alexander, D. & X. Chen. (in review). Parametric investigation of laser nanoimprinting of hemispherical cavity arrays. *Journal of Applied Physics*.
6. Shi, J., Lu, Y., Mendu, K., Cherukuri, R., Doerr, D., Alexander, D., Williams, P., Li, L., Woollam, J., & X. Chen. (in review). Laser-assisted nanoscale local deposition of diamond-like carbon films on W-tips. *Applied Physics Letter*.
7. Li, L., Lu, Y., Mendu, K. & D. Alexander. (in preparation). Photonic bandgap structure fabrication with dual-size silica particles and analysis of photonic properties.
8. Li, L., Lu, Y., & D. Alexander. (in preparation). Multiple-layer circular cavity array fabrication with laser nanoimprinting.
9. Li, L., Lu, Y., Doerr, D., Alexander, D., Shi, J., & Li, J. (2003). Fabrication of Hemispherical Cavity Arrays on Silicon Substrates Using Laser-Assisted Nanoimprinting. *Proc. New Developments in Thermal Aspects of Material Removal Processes*, 55-62.
10. Deshpande, D., Malshe, A., Stach, E., Radmilovic, V., Alexander, D., Doerr, D., & Hirt, D., (in preparation). Investigation of femtosecond laser assisted nano and microscale modifications in lithium niobate.
11. Stach, E., Radmilovic, V., Deshpande, D., Malshe, A., Alexander, D., & D. Doerr. (2003). Nanoscale surface and subsurface defects induced in lithium niobate by a femtosecond laser. *Applied Physics Letters*, 83(21) 4420-4422.
12. Stach, E., Radmilovic, V., Deshpande, D., Malshe, A., Alexander, D., & D. Doerr. (2003 December). Nanoscale surface and subsurface defects induced in lithium niobate by a femtosecond laser. *Virtual Journal of Ultrafast Science*. <http://www.vjulfast.org>.
13. Chilson, P., Yu, T.-Y., Strauch, R., Muschinski, A., & Palmer, R. (2003). Implementation and validation of range imaging on a UHF radar wind profiler. *Journal of Atmospheric and Oceanic Technology*, 20(7), 987-996.
14. Russell, D. & Palmer, R. (2004). Application of APES to adaptive arrays on the CDMA reverse channel. *IEEE Transactions on Vehicular Technology*, 53(1), 3-17.
15. Cheong, B., Hoffman, M., & Palmer, R. (2004). Efficient atmospheric simulation for high resolution radar imaging applications. *Journal of Atmospheric and Oceanic Technology*, 21, 374-378.

16. Muschinski, A., Chilson, P., Yu, T.-Y., Strauch, R., & Palmer, R. (in review). Observations of fine-scale structure and dynamics of the interface capping a continental stratus cloud. *Journal of the Atmospheric Sciences*.
17. Cheong, B., Hoffman, M., Palmer, R., Frasier, S., & Dekker, F. (in review). Pulse pair beamforming and the effects of reflectivity field variations on imaging radars, *Radio Science*.
18. Fernandez, J., Palmer, R., Chilson, P., Haggstrom, I., & Rietveld, M. (in review). Range imaging observations of PMSE using the EISCAT VHF radar: Phase calibration and first results. *Annales Geophysicae*.
19. Le, K., Hoffman, M., & Palmer, R. (in review). Comparison of antenna array systems using OFDM for software radio via the SIBIC model. *EURASIP Journal of Applied Signal Processing*.
20. Alexander, D. (in review). Micromachining of AT cut quartz using 50 femtosecond laser pulses. *Laser Institute of America*.
21. Vina, A., Gitelson, A., Rundquist, D., Keydan, G., Leavitt, B., & Schepers, J. (in press). Monitoring maize (*Zea mays* L.) phenology with remote sensing. *Agronomy Journal*.
22. Rundquist, D., Perk, R., Leavitt, B., Keydan, G., & Gitelson, A. (in press). Collecting spectral data over cropland vegetation: using machine positioning versus hand-held positioning of the sensor. *Computers and Electronics in Agriculture*.
23. Dall'Olmo, G., Gitelson, A., & Rundquist, D. (2003). From terrestrial vegetation to turbid productive waters: toward a unified approach for remote estimation of chlorophyll-a. *Geophysical Research Letters*, 30(18), 1938-1941.
24. Streck, N., Rundquist, D., & Connot, J. (2003). Spectral signatures of selected soils. *Brazilian Journal of Agrometeorology*, 11(1), 181-184.
25. Gitelson, A., Vina, A., Arkebauer, T., Rundquist, D., Keydan, G., Leavitt, B., & Verma, S. (2003). Remote estimation of leaf area index and green leaf biomass in maize canopies. *Geophysical Research Letters*, 30(5), 1248-1251.
26. Gitelson, A., Verma, S., Vina, A., Rundquist, D., Keydan, G., & Arkebauer, T., (2003). Technique for remote estimation of canopy CO₂ fluxes. *Geophysical Research Letters*, 30(9), 1486-1489.
27. Gitelson, A., Stark, R., Grits, U., Rundquist, D., Kaufman, Y., & Derry, D. (2002). Vegetation and soil lines in visible spectral space: a concept and technique for remote estimation of vegetation fraction. *International Journal of Remote Sensing*, 23(13), 2537-2562.
28. Streck, N., Rundquist, D., & Connot, J. (2002). Estimating residual wheat dry matter from remote sensing measurements. *Photogrammetric Engineering and Remote Sensing*, 68(11), 1193-1201.
29. Gitelson, A., Kaufman, Y., Stark, R., & Rundquist, D. (2002). Novel algorithms for remote estimation of vegetation fraction. *Remote Sensing of Environment*, 80, 76-87.

IV. List of Patents Pursued by the ARS CRT

“Reducing Adverse Effects of Dislodged Particles during Laser Scribing and Machining of Materials,” January 11, 2003

V. Participation in Professional Events

1. Alexander, D. R. (2003, July 21-25). Short-time fluorescence from corn and soybean plants. Research presented at the *2003 International Geoscience and Remote Sensing Symposium*: Toulouse, France.
2. Alexander, D., Chaitanya, T., & Schnell, J. (2003, August 4). Femtosecond laser induced breakdown spectroscopy advantages. Research presented at *the Laser Induced Breakdown Spectroscopy Workshop (LIBS)*, John Hopkins University: Baltimore, MD.
3. Li, L., Lu, Y., Doerr, D., Shi, J., & and K. Zhu. (2003, October 13-16). Fabrication of Hemispherical Cavity Arrays on Silicon Substrates Using Laser-Assisted Nanoimprinting. Research presented at *ICALEO*: Jacksonville, FL.
4. Lu, Y., Li, L., Shi, J., & D. Doerr. (2003, April 24-26). Nanomanufacturing using laser beam in combination with scanning probe microscope and self-assembled nanoparticles. Research presented at the *First International Symposium on Nanomanufacturing*: Boston, MA.
5. Lu, Y., Li, L., Shi, J., Alexander, D., & D. Doerr. (2003, May 19). Laser-assisted nanofabrication. Research presented at the *NSF EPSCoR Annual Conference*: Stillwater, OK.
6. Li, L., Lu, Y., Doerr, D., Shi, J., Li, J., & D. Alexander. (2003, June 10-12). Fabrication of hemosphical cavity arrays on silicon substrate using laser-assisted nanoimprinting Research presented at the *NSF Workshop on Research Needs in Thermal Aspects of Material Removal*: Stillwater, OK.
7. Stach, E., Radmilovic, V., Deshpande, D., Malshe, A., Alexander, D., & D. Doerr. (2004). Investigation of Femtosecond Laser-assisted Micromachining of Lithium Niobate. Paper invited to be presented at the *2004 Annual CIRP Meeting*.
8. Kim, S., Ji, S., & Palmer, R. (2003, April 25). High resolution spectral estimation for SAR imaging. Research presented at the *123rd Annual Nebraska Academy of Sciences*: Lincoln, NE.
9. Cheong, B., Hoffman, M., Palmer, R., Tong, H., Frasier, S., & Lòpez-Dekker, F. (2003, April 23-25). Pulse pair beamforming and the effects of reflectivity field variations on imaging radars. Research presented at the *NCAR Radar Development and Applications Workshop*: Boulder, CO.
10. Cheong, B., Hoffman, M., Palmer R., Frasier, S., & Lòpez-Dekker, F. (2003, May 20-27). Pulse pair beamforming and the effects of reflectivity field variations on imaging radars. Research presented at the *Proc. Tenth International Workshop of Technical and Scientific Aspects of MST Radar*: Piura, Peru.
11. Tong, H., Tellabati, V., Palmer, R., Hoffman, M., Frasier, S., & Lòpez- Dekker, F. (2003, May 20-27). Observations of fine-scale structure in the boundary layer using the turbulent eddy profiler. Research presented at the *Proc. Tenth International Workshop of Technical and Scientific Aspects of MST Radar*: Piura, Peru
12. Fernandez, J., Palmer, R., Chilson, P., Häggström, I., & Rietveld, M. (2003, May 20-27). Observations of PMSE using range IMaging (RIM) on the EISCAT VHF radar: Phase calibration issues. Research presented at the *Proc. Tenth International Workshop of Technical and Scientific Aspects of MST Radar*: Piura, Peru.
13. Fernandez, J., Palmer, R., Chilson, P., Häggström, I., & Rietveld, M. (2003, June 15-20). Range IMaging (RIM) observations of PMSE using the EISCAT VHF radar: Phase

- calibration issues. Paper presented at the *2003 Summer NSF CEDAR Workshop*: Longmont, CO.
14. Perez, L., Anderson, M., Boye, A., Palmer, R., & Srinivasan, S. (2003, June 22-25). An integrated signals and systems laboratory at the University of Nebraska: Lab philosophy and study design. Research presented at the *ASEE Annual Conference*: Nashville, Tennessee.
 15. Chilson, P., Palmer, R., Fernandez, J., Häggström, I., & Rietveld, M. (2003, August 25-29). *Range IMaging (RIM) studies of polar mesosphere summer echoes*. Paper presented at the European Incoherent Scatter (EISCAT) 2003 Workshop: Menlo Park, CA.
 16. Cheong, B., Hoffman, M., Palmer, R., Tong, H., Tellabati, V., Frasier, S., & López - Dekker, F. (2003, September 14-20). Optimized phased array design for the mitigation of clutter due to biological targets. Research presented within the *Proceedings of the 6th International Symposium on Tropospheric Profiling: Needs and Technologie*: Leipzig, Germany.
 17. Muschinski, A., Chilson, P., Yu, T.-Y., Strauch, R., Palmer, R. (2003, September 14-20). 915-MHz radar range-imaging observations of the interface capping a continental stratus layer. Research presented within the *Proceedings of the 6th International Symposium on Tropospheric Profiling: Needs and Technologies*: Leipzig, Germany.
 18. Le, K., Hoffman M., Palmer, R.(2003, September 22-23). Three-dimensional propagation model for wireless LAN distribution of software radio. *Proceedings of the Institution of Electrical Engineers colloquium on DSP Enabled Radio*: Scotland, UK.
 19. Srinivasan, S., Perez, L., Palmer, R., Anderson, M., & Boye, A. (2003, November 5-8). *Assessing laboratory effectiveness in electrical engineering courses*. Paper presented at the *Frontiers in Education Conference*: Boulder, Colorado.
 20. Le, K., Hoffman, M., Palmer, R. (2003, November 16-19). A stochastic image-based indoor channel model for use in ultrawideband 3-d sensor array simulations. *Proceeding of the 2003 Institution of Electrical Engineers Conference on Ultra Wideband Systems and Technology*: Washington DC.
 21. Kim, S., & Palmer, R. (2004, April 16). High resolution spectral estimation applied to SAR imaging. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE, 20.
 22. Burkholder, J., Rundquist, D., Gitelson, A., Perk, R., & Leavitt, B. (2003, April 25). Remote estimation of leaf area index in corn canopies. *Proceedings of the 123rd Annual Nebraska Academy of Sciences*: Lincoln, NE, 22.
 23. Moon, J., Rundquist, D., Perk, R., & Leavitt, B. (2003, April 25). Remote sensing with the "AISA" hyperspectral imager. *Proceedings of the 123rd Annual Nebraska Academy of Sciences*: Lincoln, NE, 23.
 24. Gitelson, A., Vina, A., Rundquist, D., Keydan, G., & Leavitt, B. (2003, April 25). Remote detection of carbon flux in maize. *Proceedings of the 123rd Annual Nebraska Academy of Sciences*: Lincoln, NE, 63.
 25. Rundquist, D., Perk, R., Leavitt, B., & Gitelson, A. (2003). *CALMIT's airborne hyperspectral imager: a tool for monitoring natural resources*. Paper presented at the *Nebraska GIS Symposium*: Lincoln, NE.
 26. Schalles, J., Rundquist, D., & Perk, R. (2003). *Results and lessons from the Apalachicola Bay "AISA" mission*. Paper presented at the *NOAA Environmental Cooperative Science Center Annual Meeting*: Islamadora, FL.

27. Rundquist, D. (2003). *CALMIT infrastructure and programs*. Research presented at the *EROS Data Center Seminar*: Sioux Falls, SD.
28. Moon, J., Rundquist, D., Perk, R., & Seevers, K. (2002). Airborne remote sensing with the "AISA" hyperspectral imager. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE, 21.
29. Burkholder, J., Rundquist, D., Gitelson, A., Perk, R., & Leavitt, B. (2002). Remote sensing of corn canopies: new procedures and vegetation indices. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE, 21.
30. Rundquist, D., Gitelson, A., Derry, D., Ramirez, J., Stark, R., Keydan, G., & Perk, R. (2001). *Remote estimation of vegetation fraction in corn canopies*. Paper presented at the *Third International Conference on Geospatial Information in Agriculture*: Denver, CO.
31. Rundquist, D. (2001). Applications of remote sensing at CALMIT. Research presented at the *Nebraska GIS Symposium*: Lincoln, NE.
32. Rundquist, D., Gitelson, A., Derry, D., Ramirez, J., Stark, R., Keydan, G., & Perk, R. (2002). Remote estimation of vegetation fraction in corn canopies. Paper presented at the *Third European Conference on Precision Agriculture*: Montpellier, France.

VI. Follow-on Grant Proposals Submitted and Funded

ARS CRT leaders and investigators pursued a variety of additional funding opportunities during the course of the project. In total, the **ARS CRT has proposed for \$6.5 million and has secured \$1.3 million in additional non-EPSCoR funding**. The grants pursued by the ARS team are highly collaborative, involving various researchers and departments at UNL.

- Dr. Don Rundquist, Dr. Anatoly Gitelson, and Dr. John Holz, ARS collaborators at UNL, are funded by the Environmental Protection Agency titled "Development and Implementation of a Comprehensive Lake and Reservoir Strategy for Nebraska as a Model for Agricultural Dominated Systems." This grant assists in ARS research involving remote sensing of water quality and provides \$1.2 million over a three-year time period (2004-2007).
- Dr. John Schalles (Creighton University), with Rundquist and Gitelson, secured funding from Florida A&M University and the National Oceanic and Atmospheric Administration to assist in the application of remote sensing in measuring and monitoring coastal ecosystems. This grant provides \$100,000 over two years, with an additional \$100,000 likely in 2004. An important element of this project is the collaborative research and training being conducted with several historically black colleges. The airborne imaging spectrometer (AISA) is an important part of the data collection.
- Additionally, the AISA is an important component of the Carbon Sequestration Program at UNL, and thus important to ARS research. The project is funded through the U.S. Department of Energy (DOE) to Drs. Shashi Verma and Ken Cassman of UNL, with Drs. Gitelson and Rundquist as Co-Investigators.
- In December 2002, Dr. Rundquist submitted a proposal to the NASA Earth Science REASoN (Research, Education and Applications Solutions Network) titled, "Agroecosystem Analysis, Monitoring, and Modeling: A Solutions Network." This grant, which was not funded, would have complemented ARS research regarding agriculture and rangeland remote sensing and would have provided approximately \$1,000,000 per year for ARS research for five years of funding.
- A grant for "The Role of Remote Sensing in Integrated Pest Management" was recently submitted to the Vice Chancellor for Research at UNL for cluster seed research. This

application was submitted by ARS Collaborator Dr. Thomas E. Hunt, with assistance from Dr. Gary Hein, Dr. Blair Siegfried, Dr. Don Rundquist, Dr. Albert Peters, Dr. Loren Giesler, Dr. John Watkins, and Dr. Stevan Qi Hu. Although not funded, this grant would have allocated an additional \$100,000 over two years for ARS research.

VII. Confirmation of Technical Monitor Contact and Involvement

Research and collaborative contacts are maintained between ARS CRT Leader Dr. Don Rundquist and Dr. K. Jon Ranson, ARS CRT Technical Monitor, at the Biospheric Science Processing department at Goddard Space Center in Greenbelt, MD. Additionally, Dr. Rundquist maintains consistent contact with Ed Sheffner in the Office of Earth Science Applications Division at NASA Headquarters. Further research collaborations are maintained with the Commercial Remote Sensing Program at Stennis Space Center. Further collaborative action was achieved on March 11, 2004 when AERIAL Researcher Dr. Henry Lehrer briefed Dr. Ranson on ARS remote sensing activities and LPTC geospatial initiatives.

Dr. Ranson has provided confirmation of his support of ARS CRT research progress during the first three years of funding. Specifically, Dr. Ranson provided notification of his review and approval of the ARS Year 2 Report, Year 3 Proposal, the above ARS Research Area Award Report of Progress, and the following ARS Research Area Award Request for Continuation.

VIII. ARS Personnel Information

ARS CRT member	Male	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty	8		7		1	
Post-Doctoral						
Staff	9		9			
Graduate	16		9		7	
Undergraduate	1		1			

ARS CRT member	Female	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty						
Post-Doctoral						
Staff	2		2			
Graduate	5		1		4	
Undergraduate						

IX. Progress Toward Achieving Self-sufficiency Beyond Award Period

The ARS program intends to be self sufficient in the next two or three years. Due to interest in the CALMIT-AISA sensor, several scientists at UNL (and at other institutions and governmental agencies) are writing the system into their proposals to acquire research data. The ARS CRT collaborates with Dr. Paul Zimba and Dr. Jerry Hatfield of the USDA Agricultural Research Service on water quality and crop-nutrient projects, respectively. CALMIT also collaborates with Florida A&M University (e.g., Dr. Mark Harwell), which receives National Oceanic and Atmospheric Administration (NOAA) funding to study coastal processes in several states. Project missions have been flown in Mississippi, South Carolina, and Florida.

Discussions are on-going to fly the AISA (fall 2004) in tandem with NOAA's airborne Lidar sensor (used for bathymetric mapping) in support of a NOAA project in North Carolina. CALMIT has also been contacted by the Proyecto de Manejo Ambiental de Islas de la Bahia in Honduras to use the AISA for assessing coral-reef and other coastal resources.

The ARS CRT has collaborated on AISA research with the Minnesota Department of Natural Resources (water quality; George Yost), University of North Dakota (Saltcedar; Dr. Brad Rundquist), National Park Service (land cover in Texas; Dr. Gary Wilson), University of South Carolina (land cover; Dr. John Jensen), and the U.S. Department of Defense (land cover; Dr. Dwayne Porter). Continued testing of the Lidary sensor, in conjunction with Dr. Songxin Tan (South Dakota State University) should lead to a unique on-board capability for evaluating vegetation stress before it is visible, using laser research dealing with fluorescence.

X. Research Results

The ARS CRT has documented significant success since initiation in 2000. Through an NSF grant this team obtained a single-engine Piper Saratoga (Figure 1), which was modified for remote sensing in 2001 and now operates a functional, effective, and unique data-acquisition system. The Principal Investigators who successfully secured this funding were Dr. Ram Narayanan, UNL Electrical Engineering; Dr. Don Rundquist; and Dr. Brent Bowen. Immediately after purchase, the aircraft was delivered to Duncan Aviation in Lincoln, NE. Duncan technicians, using Dwerlkotte and Associates (Wichita, KS) engineering drawings, created two ports in the fuselage of the aircraft. Two aluminum instrument racks, designed for rapid installation and removal of equipment, were constructed to fit the ports. Through the use of this platform, ARS CRT research has focused on: (1) hyperspectral agricultural research; (2) modifying and testing a NASA-donated lidar sensor; (3) synthetic aperture radar development; (4) theoretical modeling of microwave backscatter; (5) stripmap synthetic aperture radar imaging; and 6) laboratory testing of laser fluorescence.



Figure 1: Piper Saratoga aircraft the AISA

A. Hyperspectral Research

The AISA hyperspectral imager allows researchers to program up to 286 spectral bands of interest. Normal operation provides 16 to 35 spectral bands. AISA's spectral sensitivity is 430-900 nm and spatial resolution is 1-3 meters. Imaging spectrometers provide specific target images and detailed spectral profiles. Some imaging spectrometers (e.g., NASA's AVIRIS) acquire data for as many as 224 individual discrete, narrow spectral channels. The ARS

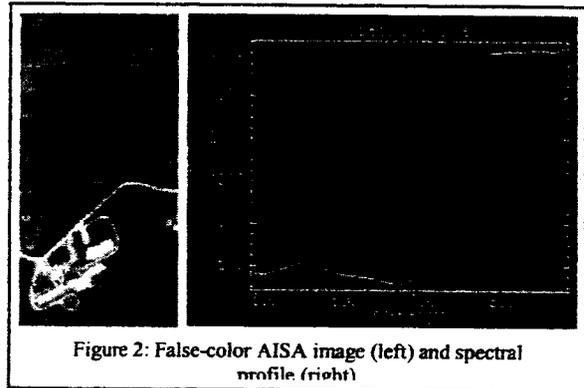


Figure 2: False-color AISA image (left) and spectral profile (right)

CRT uses ENVI software to process AISA data, allowing investigators to point at selected image pixels and display diagnostic spectral-reflectance curves. A three-band AISA image and corresponding spectral-reflectance is shown in Figure 2 (above).

In May 2001, sensor engineers at NASA Stennis Space Center tested and confirmed the need for an in-house ARS calibration facility. The device and aircraft were sent to Mississippi for test flights targeting agricultural lands, forests, and surface water. NASA technicians provided a written report to CALMIT scientists in November 2002. Stennis testing and image product evaluations both noted the need to optimize the configuration files for specific targets.

Specifically, Nebraska researchers need to identify particular spectral channels for various types of ground targets. One associated problem is that the instrument must be calibrated for each individual file, requiring the sensor to be transported to Spectrum Mapping (formerly 3Di Corporation) in Easton, MD for calibration for each new file. Early imagery revealed the presence of a cross-track banding artifact, whose source was identified as the AISA system's Analog-Digital converter. The calibration for this systemic problem could be effectively completed in-house. These continual optimization and calibration efforts, combined with the associated travel to Easton, illustrate the need for an in-house calibration facility.

The complete program is being streamlined from mission planning phase to data delivery. Macros written for ArcView have shortened flight line development time from hours to minutes, facilitating the ability to generate flight lines and accommodate weather changes as needed. A new motherboard for the AISA collection computer has improved data collection. Electrical system upgrades permit unlimited mission times (previously limited to a battery life of 2.5 hours). Adding a network card to the collection computer has enabled networking to an on-board laptop, allowing data processing from remote locations and/or in-flight. Scripts have been written to speed the post-processing procedures. Raw data is batch processed, flat-fielding corrections applied, and delivery shortened from 1-2 weeks to 1-2 days.

In 2002, CALMIT began testing the AISA over selected targets in the Midwestern U.S., focusing on the sensor's utility for practical applications. Because CALMIT had embarked on data-collection at three fields of the ARDC, irrigated and dryland corn and soybean fields were selected for AISA overflights. Collaboration between CALMIT and USDA focused on test fields in Illinois, Iowa, and Missouri, which were flown at bare soil, pre-tassel, and grain fill stages. Via an AISA mission flown over a university-owned wheat field in Western Nebraska that detected the spatial extent and severity of the Wheat Streak Mosaic Virus, the ARS CRT demonstrated its capacity to fulfill the USDA need for biophysical parameters associated with variable nitrogen applications as imaged with an airborne hyperspectral sensor.

The Branched Oak Lake (NE) and Fremont State Lakes (NE) Recreation Area were selected as AISA targets in 2003. CALMIT collected voluminous amounts of data at these sites. The work tested remote sensing as a means of assessing the characteristics of the water column. Airborne missions were conducted in support of the EPA's Science to Achieve Results (STAR) grant provided to UNL to facilitate research on remote sensing of inland waters.

Collaboration between Dr. Gitelson and Dr. Paul Zimba (USDA-Agricultural Research Service) focused on remote sensing for water-quality assessment. Because the USDA had data on water-quality parameters for its Catfish Genetics Unit's aquaculture site in Mississippi, the CALMIT AISA flew over that location. Nebraska researchers computed a ratio of reflectance to produce an estimate of chlorophyll amounts in the catfish ponds. Differences in productivity were seen not only among the various ponds but also within individual ponds. Results from these flights led to new missions in 2003. The CALMIT Hyperspectral Airborne Monitoring Program acquired data for more than a dozen research projects in 10 states.

During 2003, ten AISA missions were conducted over the "Carbon Sequestration Fields" at UNL ARDC. Supported by the DOE, this research activity involved several UNL researchers. The remote-sensing component was led by Dr. Gitelson, with Dr. Rundquist as a co-investigator. The purpose of this research linked in-situ spectral reflectance at both leaf and canopy levels to biophysical parameters of vegetation. Field spectral measurements were made using CALMIT's "Goliath" instrument platform's sensors. Research continues to relate in-situ measurements done via the Goliath system to data collected from aircraft altitudes. Figure 3 shows image datasets

collected by the AISA sensor over the carbon-sequestration fields. CALMIT researchers are linking the biophysical properties of corn and soybeans with the field-collected hyperspectral data and the AISA-overflight data. An important finding has been using remote sensing to estimate carbon-dioxide fluxes. The ARS CRT now has 3 years of data on the carbon-experimental fields, comprising an unprecedented dataset with several significant manuscripts published in peer-refereed journals.

Two locations of the "ACE (river) Basin," Charleston, SC and Grand Bay, MS, were observed during 2003 using AISA. These airborne missions were conducted in support of a grant to Creighton University and CALMIT from Florida A&M University (through NOAA funding) to examine how remote sensing might facilitate research on coastal waters and wetlands. Students from two of the historically black colleges, South Carolina State and Jackson State, collected field data in support of the AISA missions.

B. Testing of the Lidar Unit

Nebraska researchers have completed the construction of the multiwavelength airborne polarimetric lidar (MAPL) system operating at 532 and 1064 nm wavelengths, and are performing preliminary field tests, calibrating the system, and integrating the system aboard the aircraft. This system employs a Nd:YAG laser which emits radiation at two wavelengths: the fundamental at 1064 nm and the frequency-doubled at 532 nm. Both laser beams are highly linearly polarized (100:1 extinction ratio) and have a beam divergence angle of 4 mrad. The receiver consists of four channels: two for each wavelength. Each wavelength contains one channel to measure co-polarized backscatter and one channel to measure cross-polarized backscatter. In addition to the polarimetric information that can be gathered, the lidar system is capable of performing studies of vegetation canopy structure, as well as characterization of vegetation depolarization. Combining a vertical canopy structure model and the lidar range equation has resulted in a theoretical understanding of the vegetation canopy scattering. A single canopy vertical distribution is introduced, along with a so-called G-function to describe the effective leaf area index in terms of the incident radiation direction. Three typical foliage area density functions were simulated to represent different canopy shapes. Lidar waveforms from the three canopy models were obtained via simulations, and compared with the NASA SLICER airborne lidar experiment data. Agreement between the simulated and experimental waveforms was observed, thereby validating the model. Ground signal-to-noise-ratio (SNR) under a single canopy condition was also investigated by taking into account the following: signal caused quantum noise, background radiation noise, dark current, and thermal noise. System SNR values at green wavelength channels were computed to be more than 20 dB higher than those at near-infrared channels. Good SNR is obtained up to a range of 2000 m. Field measurements at a

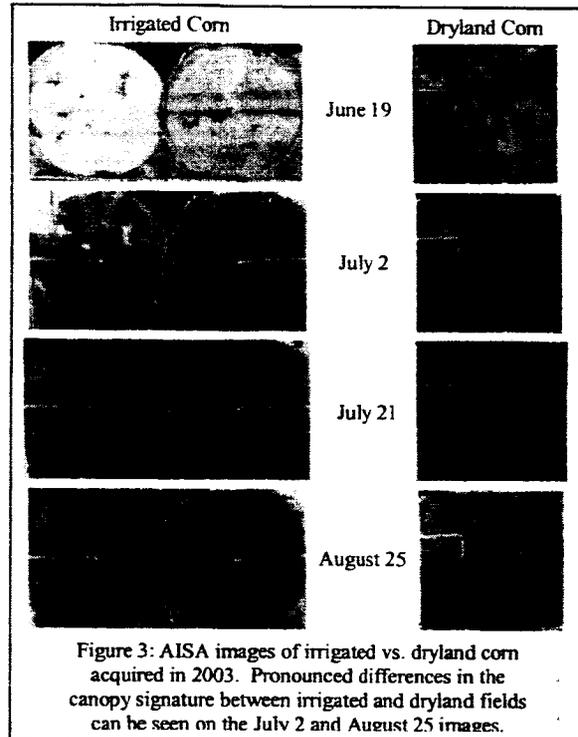


Figure 3: AISA images of irrigated vs. dryland corn acquired in 2003. Pronounced differences in the canopy signature between irrigated and dryland fields can be seen on the July 2 and August 25 images.

range of 1500 m show that the system is able to probe canopy structure. The system has been packaged to fly aboard the Piper Saratoga aircraft from a height of up to 1000 m.

C. Synthetic Aperture Radar

The CRT completed the breadboard development of the synthetic aperture radar (SAR) system operating over the 9.8-10.2 GHz frequency band, and is currently packaging the system to mount within the aircraft. SAR is one of the main tools for microwave remote sensing because of its multi-dimensional high-resolution imaging capability and its ability to operate in nearly all weather conditions, day and night. UNL commenced the design and development of low-cost airborne SAR in January 2001. The objectives of this project were to construct and deploy an imaging radar system using basic RF/microwave components for the remote sensing of underlying biophysical parameters aboard an airborne platform from heights up to 1,500 meters. The SAR system is an X-band, stepped-chirp FM, single polarization radar system. One of the unique features of the system is that the signal generation consists of a timing-controlled D/A converter and VCO arrangement to generate the stepped-chirp signal, thereby allowing for less design complexity and lower overall system cost. The individual block segments including waveform generation, transmit and receive hardware, antennas, quadrature detection and image signal processing have been finalized and tested. The microwave system of the SAR has been designed and constructed and is under calibration and testing. Preliminary field tests have already been conducted on a variety of terrains.

D. Theoretical Modeling

The CRT commenced theoretical efforts to model the microwave scattering from leaves and crop canopies. Microwave scattering models have been developed for natural media to analyze scatterometer and SAR measurement data and retrieve target biophysical parameters. ARS researchers are developing a four-component microwave scattering model including: (1) the generalized Rayleigh-Gans (GRG) approach, (2) the physical optics (PO) approach, (3) a comparison between the corrected cylinder scattering amplitude formula and the original formula, and (4) a precise numerical computation algorithm development, combining radiative transfer theory with theoretical simulation of scattering. Theoretical simulation based on this improvement is conducted for scattering from corn canopies. Also investigated is the application of the method of moments (MoM) in leaf scattering, by solving the equivalent surface electric current and magnetic current through matrix equations, and evaluating the scattering cross sections using known currents. MoM has several advantages for the computation of scattering problems from irregular and homogeneous dielectric objects, and generally provides the most accurate numerically computed results. The widely used Rao-Wilton-Glisson (RWG) functions are used as basis functions in our MoM computations. Since the thickness of a leaf is very thin compared to the wavelength, the impedance approach is used to solve the dielectric scattering problem. The scattering cross section of a leaf for different shapes and thickness computed using the MoM method compares well with the results using the GRG and PO approximations.

E. Stripmap Synthetic Aperture Radar (SAR) Imaging

ARS researchers focused on the airborne platform of SAR imaging, a high-resolution method of estimating the reflectivity from the field of view of an airborne or spaceborne radar system. The estimated reflectivity field of the target area was mapped into range and cross-range domains. In a stripmap SAR imaging system, the terrain map shifts in the cross-range domain as the platform moves. At each synthetic aperture position along the path of the airplane, the radar transmits a wide-bandwidth pulsed chirp signal and collects the backscattered signal from the illuminated target area. The SAR signal measures amplitude and phase information for each

target point. Hence, an imaged scene is reconstructed by estimating target amplitude from a history of time delay information.

ARS simulated data resulted from twelve points both inside and outside of a specific target area. A specific pulsed chirp signal was transmitted in order to collect time delay information from the target region. Several radar parameters were set to match the x-band SAR system, a proposed component of this NASA-funded project. After transmission of the chirp signal, the reflected time-delayed signal from the point targets resulted in a specific SAR signal. NASA EPSCoR funding allowed the ARS CRT to conduct this thorough theoretical study of SAR imaging algorithms. Additionally, actual x-band SAR data were obtained via collaboration with the Sandia National Laboratory airborne system. It is believed these data will provide the mechanism needed to finalize the ARS CRT's study of SAR reconstruction.

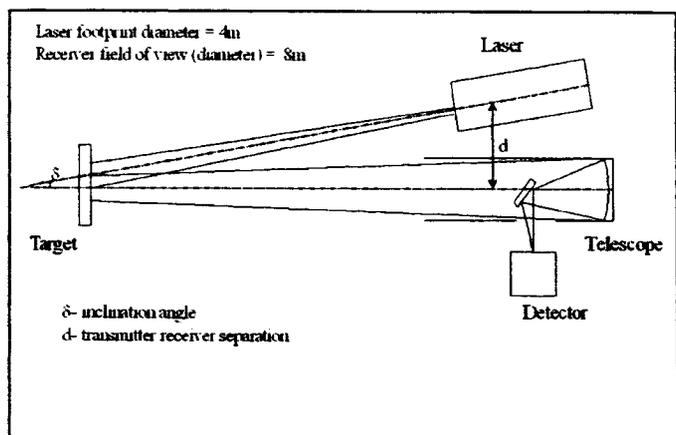
F. Remote Sensing Applications Using Short Time Gated Fluorescence

Of particular relevance to Nebraska economy and national security is the ARS laboratory research performed using fluorescence from the emission peaks emitted from corn, soybean, and deciduous trees or shrubs under simulated lack of water stress as a means for monitoring drought conditions. The important finding in this research is that the fluorescence signal emitted in the first 50 ns is 2-3 times the signal that is emitted in the time frame greater than 200 ns. Additional research was conducted to investigate the fluorescence emission from chlorophyll in green algae. Surprisingly, the emission peaks of green algae occur at a different wavelength than the emission from plants. Corn and soybeans fluorescence is a much longer process as compared to green algae. This means that the algae are able to convert the photon energy into electrical processes at a faster rate than plants. Studies have been carried out to investigate the use of this short time fluorescence to determine when a virus attacks the membrane of the chlorella cell.

Since it takes approximately 20 minutes for the virus to penetrate the chlorella cells short time fluorescence shows usefulness as a remote sensing tool. An EE 494/EE 495 senior design group is working on a very small portable detection system to monitor this fluorescence to analyze virus attacks on cells. This research is expected to have significant National Security implications and, thus, eligible to be funded via federal agencies other than NASA. The final phase will extend the studies beyond the laboratory. Based on recent studies, the following design should be capable of detecting short

time fluorescence from 3000 ft. The detector is an ocean Optics HR 2000, with a spectral range from 200 nm to over 1100 nm. Extensive laboratory studies have determined the required laser power needed at the footprint in order to detect the background signals. Figure 4 (right) is an original ARS CRT design, being built to be placed aboard the ARS aircraft. Details of this work are published in two conference papers and two journal papers being prepared for review. Master Thesis projects

regarding this subject are being prepared by Mr. Chaitanya Thatipamula and Ms. Sireesha Parvatham. A final project report will be presented by the EE 494/495 senior design team.



Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Request for Continuation for the

**Airborne Remote Sensing for Agricultural Research and Commercialization Applications
(ARS) Collaborative Research Team (CRT)**

XI. Two-Year Program Plan and Budget

The ARS CRT proposes the following research for Years 2005 and 2006 to build on the past 3 years' successes in obtaining the aircraft, modifying it for remote sensing, and finally installing and integrating that sensor within the aircraft platform. The ARS CRT will emphasize enhancement of technological infrastructure and development of solid applications of remote sensing to practical problems. The proposed projects promise to provide not only technological enhancement of capabilities at UNL but also a unique mix of basic and applied research.

The team requests continuation funding for the following research projects: (1) hyperspectral research, with an emphasis on agriculture; (2) testing of the lidar unit; (3) development of a synthetic aperture radar; (4) theoretical modeling of microwave backscatter; (5) stripmap synthetic aperture radar imaging; and 6) laser fluorescence. In response to the departures of ARS CRT researchers, resources will be redirected for the next two years. This departure of researchers has allowed for the unique opportunity for Dr. Don Rundquist to assume the role of ARS Principal Investigator. Please see Attachment 1 for Dr. Rundquist's CV.

Based on the success of the ARS CRT hyperspectral program, the intense interest in the AISA sensor, and the potential for practical application, the ARS CRT will accelerate the AISA aspect of their work during the next two years. The first step to enhance that effort includes three AISA-oriented projects proposed for 2005.

**A. Development of a Calibration Facility at UNL for the AISA Instrument –
Don Rundquist, Lead Researcher**

As noted in the ARS Report of Progress, when an AISA configuration file is established, a new calibration of the sensor must follow, resulting in continual transport of the sensor to Easton, MD. This is a costly undertaking, depleting resources by \$2-3.5k per visit. To eliminate this costly expenditure, the ARS CRT proposes to establish for the AISA imaging spectrometer an in-house calibration facility within existing CALMIT facilities at UNL. This would include the development of a laboratory to house the necessary AISA calibration activities. The major components of this facility will include 1) a Uniform Radiance Standard (URS); 2) an integrating sphere; and 3) a regulated DC constant power supply. Don Rundquist, Anatoly Gitelson, Rick Perk, Bryan Leavitt, Nick Emanuel, Mr. Mike Hauschild will collaborate on this endeavor.

With continued NASA EPSCoR funding, the following items would be incorporated into the calibration laboratory:

- 1) A Uniform Radiance Standard (URS): a calibrated integrating sphere light source with a regulated DC constant current power supply for calibration of imaging and non-imaging radiometers.
- 2) An integrating sphere: a tool for producing a highly uniform distribution of light.
- 3) A portable calibration system: to move the calibration facility to the aircraft, eliminating the downtime that removes the aircraft from service for at least a full day during each phase of the removal/ reinstallation of the AISA system components from the aircraft, as well as no longer subjecting the system to unstable conditions.

B. Remote Sensing of Bean Leaf Beetle / Bean Pod Mottle Virus – Don Rundquist, Lead Researcher

The ARS CRT is tying their remote sensing work to an important issue concerning Nebraska agriculture which has received high visibility statewide. The Bean Leaf Beetle carries the Bean Pod Mottle Virus from plant to plant. Once infected, the leaves may show a slight yellow mottling, but there are few visible signs. The disease can spread quickly through a field. The ARS researchers propose to showcase the AISA sensor as a tool for studying this problem, by linking spectral-reflectance data with field-measured insect counts and leaf-damage assessments. This would be accomplished by utilizing the experimental fields operated by the Department of Plant Pathology at UNL. Spectral-reflectance data will be collected in-situ on a weekly basis of these fields. CALMIT researchers will use the “Goliath” instrument platform, dual Ocean Optics spectroradiometers, and the AISA to collect the needed data. The data collection in the field will be contributed by CALMIT. Don Rundquist, Anatoly Gitelson, Loren Geisler, Tom Hunt, Bryan Leavitt, Galina Keydan, Mike Hauschild, and Amy Ziems, will collaborate on this project.

C. Remote Sensing of Biophysical Parameters of Corn and Soybeans – Anatoly Gitelson, Lead Researcher

The on-going collaborative project with ARDC is the highest quality carbon-sequestration research effort in an agricultural setting to be found anywhere in the world. During 2004, three large fields (each >130 ac.) will again be used for research. One field will be planted to irrigated corn, one to irrigated soybeans, and one to non-irrigated soybeans. The ARS researchers propose to link selected biophysical parameters of vegetation (e.g., fraction of cover, absorbed photosynthetically active vegetation (APAR), live green biomass, leaf area index (LAI), and chlorophyll density), as measured in-situ at both leaf and canopy scales, to AISA data. These parameters will be estimated over large geographic areas using airborne and (eventually) satellite data.

A total of 4 AISA missions will be conducted over the carbon-sequestration experimental fields during the 2004 growing season. Imagery will be flown at a spatial resolution of three meters using 35 spectral channels. Field measures of spectral reflectance in more than 2,000 individual channels will be collected at least 30 times during Year 4; at least three of which will occur concurrent with the AISA missions. Other ancillary data to be collected in-situ include fraction of cover, APAR, live green biomass, LAI, and chlorophyll density in the leaves. The field data collection will be contributed through collaboration with CALMIT. Anatoly Gitelson, Don Rundquist, Rick Perk, Bryan Leavitt, Galina Keydan, Mike Hauschild, Nick Emanuel, and Veronica Ciganda will collaborate on this project.

D. Airborne Testing of UNL Lidar Sensor – Songxin Tan, Lead Researcher

In an endeavor to fly the Lidar sensor during Year 4, the CRT will continue collaboration with Dr. Ram Narayanan, now with the Department of Electrical Engineering at Penn State University, and previously the lead investigator for the Lidar sensor. The CRT will also partner with Dr. Xongsin Tan, former graduate student of Dr. Narayanan and builder of our Lidar instrument. Dr. Tan is now a faculty member with the Department of Electrical Engineering at South Dakota State University. The UNL Lidar instrument will be made available to Dr. Tan for testing. The objective of this project is to test the Lidar sensor described in the cumulative summary (above) with regard to its utility in assessing biophysical characteristics of crops. During Year 4, the sensor will be tested over crops in both South Dakota and Nebraska, with the focus of the work to be on Lidar measurements of the carbon-sequestration fields at ARDC.

Spectral-reflectance data for those fields will be collected in-situ on a weekly basis. CALMIT researchers will use the "Goliath" instrument platform and dual Ocean Optics spectroradiometers. AISA data for these fields will be compared to the Lidar measurements. Songxin Tan, Ram Narayanan, Dr. Don Rundquist, and various graduate students will collaborate on this project.

E. Development of Synthetic Aperture Radar (SAR) – Don Rundquist, Lead Researcher

Because of the departure of Dr. Ram Narayanan from the University of Nebraska in August of 2003, the project to develop an airborne radar scatterometer for the Piper Saratoga will be placed on temporary hold. Discussions between Rundquist and Narayanan continue with regard to the installation of the SAR sensor in the Piper Saratoga. There are issues regarding adequate aircraft electrical power for the SAR, and ultimate FAA approval. Although progress regarding SAR will be halted during Year 4, useful outcomes from this project have already been realized for proposed research in Year 5. For example, the system has been field tested. Also, Mr. Paul Cantu, the student who developed the SAR sensor, received his Masters in Electrical Engineering during 2003. New progress will continue in Year 5.

F. Laser Fluorescence – Dennis Alexander, Lead Researcher

Dr. Dennis Alexander, Department of Electrical Engineering, UNL, will lead the laser-fluorescence portion of ARS research. As described in the ARS Research Area Award Report (above), this project is of particular relevance to Nebraska economy and national security. The goal of this project is to create a very portable system to analyze virus attacks on cells. Exciting new results have already been obtained through Dr. Alexander's research. This project will be continued well into 2006.

G. Development of an Airborne Fluorescence Sensor – Dennis Alexander, Lead Researcher

During 2002 and 2003, laboratory research was conducted on the short time fluorescence from corn and soybean plants. In addition, research was conducted on the fluorescence from green algae. During 2004 and 2005, the laboratory system will be adapted for placement aboard the University of Nebraska Remote Sensing Aircraft. Preliminary research has designed the system to have sensitivity to fluorescence from plants at a flying altitude of 3,000 feet with a footprint of 1 meter. The system has been designed to operate with the Ocean Optics HR 2000 spectrometer that has a spectral range from 200 nm to over 1100 nm. Preliminary research has demonstrated that this spectrometer is more sensitive and less noisy than the Princeton Instruments intensified OMA system. During the next two years of research, the objectives are to install the system in the UNL aircraft and perform field studies. These studies will be performed on plots of corn and soybeans under various simulated degrees of stress from drought. After the initial studies have been performed to work out in-flight measurement problems, the system will be flown over a number of sites to monitor the drought conditions. Preliminary research indicated the ability to distinguish between old and young plants. Research will be performed to determine if this can also be detected at altitude. Laboratory research will continue on the fluorescence from Chlorella cell infected with viruses. In particular, the ARS team is interested in working with Dr. Van Etten to develop a better method for detecting anti-virus agents that prevent the attack of the virus on the cell. The short time fluorescence techniques look promising for developing a rapid method to detect this. The current method uses an incubation method that takes several days for the tests to come back. Dennis Alexander and James Van Etten, will collaborate on this project.

H. Termination of Theoretical Modeling and Stripmap Synthetic Aperture Radar Imaging

Due to Dr. Ram Narayanan's departure from the University of Nebraska in August 2003, the ARS project aimed at theoretical modeling of microwave backscatter has been terminated. Resources originally projected for this activity will be redirected to enhance and accelerate the hyperspectral program.

Dr. Robert Palmer was leader of the Stripmap Synthetic Aperture Radar Imaging project. However, Dr. Palmer has accepted a position with the University of Oklahoma following the spring semester of 2004. Resources originally projected for this activity will also be redirected to the hyperspectral program.

I. The Utility of Remote Sensing for Monitoring Invasive Species: The Example of Saltcedar – Don Rundquist, Lead Researcher

As CALMIT faculty members establish collaboration with the USDA's Animal and Plant Health Inspection Service (APHIS) program, one topic of discussion involves the invasion of Saltcedar into Nebraska. ARS experience in examining AISA data for strands of that species in North Dakota leads the team to conclude that there is potential for identifying Saltcedar and monitoring its spread in our state. The opportunity to collaborate with USDA investigators in solving practical problems by means of remote sensing is both important and attractive to the ARS CRT. This project's objective is to test the utility of AISA hyperspectral data for identifying, digitally classifying, and mapping the spatial distribution of Saltcedar in a selected Nebraska Study Site. This will be accomplished by conducting 3 AISA overflights during the growing season that are considered important by the USDA investigators. This project will cultivate the established collaboration between ARS CRT members, Don Rundquist and Rick Perk, and Dr. Steve Johnson of the USDA.

J. Remote Sensing of Soybean Rust: Monitoring Nebraska's "Sentinel Sites" – Don Rundquist, Lead Researcher

CALMIT faculty members are also collaborating with USDA APHIS staff on a project concerning soybean rust. The ARS CRT has the unique opportunity to become involved in this emerging research area, which is not yet being pursued in the U.S. APHIS is interested in having CALMIT monitor 12 sentinel sites in Nebraska over the course of one growing season with the intent to detect infestations of soybean rust as it occurs. This project has links to homeland-security efforts. The objective of this project is to test the utility of AISA hyperspectral data for identifying early occurrences of soybean rust in selected Nebraska study sites. To achieve this objective, the ARS CRT will conduct 4 AISA overflights over 12 selected sentinel sites during one growing season. This project will enhance the collaboration between Don Rundquist, Rick Perk, and Steve Johnson.

K. AISA Sensor and the UNL Carbon-Sequestration Program – Anatoly Gitelson, Lead Researcher

The ARS CRT anticipates continued research on biophysical parameters associated with corn and soybeans. The objective of this research is to link selected biophysical parameters of vegetation (stated earlier), as measured in-situ at both leaf and canopy scales, with AISA data. This will be accomplished by conducting 4 AISA missions over the carbon-sequestration experimental fields during the 2006 growing season. Imagery will be flown at a spatial resolution of three meters using 35 spectral channels. Field measures of spectral reflectance in more than 2,000 individual channels will be collected at least 30 times during the 2004 growing season; at least three of which will occur concurrent with the AISA missions. Other ancillary

data to be collected in-situ are fraction of cover, APAR, live green biomass, LAI, and chlorophyll density in the leaves. Field data collection will be contributed by CALMIT as a match on the project. Anatoly Gitelson and Don Rundquist will collaborate on this project.

L. Installing, Testing, and Applying a Thermal-Infrared Remote Sensor to Natural-Resources Issues in Nebraska – Don Runquist, Lead Researcher

Although the Piper Saratoga carries the AISA, it would be highly desirable to install and operate a thermal-infrared (TIR) imager aboard the aircraft. TIR sensing offers the capability to infer the temperature of ground targets, as well as produce images of temperature patterns across geographic space. Practical applications include tracing thermal pollution in water bodies (e.g., from power plants and sewage outfalls), mapping groundwater seeps in lakes and streams (e.g., in the Nebraska Sandhills), monitoring the temperature of vegetation canopies (e.g., stressed vegetation has a higher temperature than unstressed), and imaging urban areas (e.g., assessing the quality of rooftop insulation, effects of urban heat islands, etc.). This project's objective is to install a TIR sensor on the Piper Saratoga, and produce test images of various types of ground targets including vegetation canopies, water bodies, and urban areas while working toward providing practical solutions to Nebraska problems in the natural-resources arena. To complete this objective, the ARS CRT will purchase a Raytheon Commercial Infrared Radiometric PalmIR-500 digital imager. This is a light-weight sensor with a focal-plane array of 320 x 240 pixels. The digitizing resolution is 12 bits, and the detector sensitivity exceeds 0.1 degrees C. The wavelength sensitivity is 7-14 microns. The sensor would be installed in the Piper Saratoga and tested over Nebraska sites of interest. Don Runquist would complete this project with assistance from Rick Perk and other Nebraska researchers.

XII. Metrics for Tracking and Evaluating Program Progress

The metrics for tracking and evaluating program progress include: frequent meetings with graduate students assisting with the project; occasional meetings with co-investigators, project staff and other collaborators; twice yearly updates to Advisory Committee members at TAC meetings; quarterly as well as annual reports; regular presentations at professional meetings including the annual meeting of the Nebraska Academy of Sciences; occasional invited special presentations such as the recent after-dinner lecture given by Dr. Rundquist and Rick Perk at Nebraska Agricultural Technologies Association meeting in Grand Island; and peer review of submitted manuscripts.

We also evaluate program progress by judging the level of interest, both within Nebraska and in other states, in our sensor array and the number of requests that we receive inviting us to collaborate on research projects and proposals. For example, our group has received an ever-increasing number of requests to collaborate on projects where AISA data are to be exploited in addressing agricultural and natural-resources issues. Such collaborations provide the financial stability to continue the airborne remote-sensing program.

Maintaining research and collaborative contacts with Technical Monitor Dr. K. Jon Ranson of Goddard Space Flight Center will continue to be a priority for the ARS CRT during Years 4 and 5. In an effort to remain consistent with NASA's Mission, Dr. Ranson provided confirmation of the ARS Request for Continuation.

XIII. Milestones & Timetables for Achieving Specific Objectives During Award Period

The ARS team has specific plans for expected research endeavors during Years 4 and 5. These projects are listed below.

A. Year 4

- Airborne Testing of UNL Lidar Sensor
- Development of Synthetic Aperture Radar
- Laser Fluorescence
- Development of an Airborne Fluorescence Sensor

B. Year 5

- Development of a UNL AISA Calibration Facility
- Remote Sensing of Bean Leaf Beetle / Bean Pod Mottle Virus
- Remote Sensing of Biophysical Parameters of Corn and Soybeans
- Laser Fluorescence
- Development of an Airborne Fluorescence Sensor
- Remote Sensing for Monitoring Invasive Species
- Remote Sensing of Soybean Rust: Monitoring Nebraska's "Sentinel Sites"
- AISA Sensor and the UNL Carbon-Sequestration Program
- Installing, Testing, and Applying a Thermal-Infrared Remote Sensor to Natural-Resources Issues in Nebraska

XIV. Potential to Achieve Self-sufficiency Beyond the Award Period of This Grant

The original goal for the ARS CRT was to arrive at self-sufficiency five years after the purchase of the aircraft. The CRT's success in securing \$1.3 million in non-EPSCoR funding as a result of the experience and knowledge gained from the first three years of our EPSCoR work leads us to conclude that this was a realistic goal and will be achieved.

Continued testing of the Lidar sensor should lead to lucrative national and international collaborations. Scientists from across the globe have been contacting the ARS CRT to indicate their interest in using the AISA and Lidar sensor in their research. Such collaborations indicate the possibility of further non-EPSCoR funding.

The laser fluorescence portion of ARS research holds significant relevance to Nebraska economy and homeland security. Development of a very portable system to analyze virus attacks on cells merits National Security implications and, thus, eligible to be funded via federal agencies other than NASA.

Installation of a TIR sensor on the Piper Saratoga will offer practical solutions to Nebraska's natural resources issues, and open opportunities for further non-EPSCoR funding.

Practical applications for agricultural purposes, such as ARS research devoted to Remote Sensing of Bean Leaf Beetle / Bean Pod Mottle Virus and Remote Sensing of Biophysical Parameters of Corn and Soybeans open doors for additional revenue streams. The Utility of Remote Sensing for Monitoring Invasive Species: The Example of Saltcedar and Remote Sensing of Soybean Rust will strengthen collaborations with the USDA.

XV. Potential for Future Growth in Importance in Aerospace Fields

The demand for individuals trained in the geospatial technologies (remote sensing, geographic information systems, global positioning systems, digital image processing) is strong

and increasing. The ARS CRT is involved in training students in the use and application of these technologies regarding natural resources issues, and the team's researchers can attest to that strong demand. The ARS CRT's collaborative experience with colleagues in Engineering suggests that the same is true for their students. This team is often contacted by employers with requests for trained personnel (i.e., students who have completed or are near completion of degree programs). A recent article in *Nature* (Vol. 427, January 22, 2004) states "Job opportunities are growing and diversifying as geospatial technologies prove their value in ever more areas." The article goes on to state that "...the U.S. \$5 billion worldwide geospatial market will grow to \$30 billion by 2005...." Additionally, the new emphasis on homeland security can only lead to even more employment for students trained in remote sensing and GIS. These outreach and technology transfer efforts are designed to self-fulfill the demand created by the unique mix of basic and applied research proposed by ARS.

ARS aims to increase the capability to produce, analyze, and understand science and mission data, as well as to develop a suite of simulations and data products. Among NASA's topics of relevance related to their Aeronautics mission is the increasing use and application of low-cost on-demand remote sensing capabilities. Examples of applications include monitoring of compliance with emission regulations, land use and land cover characteristics, and disasters such as hurricanes and floods. These objectives would require the development of improved remote sensing systems operating from airborne platforms, demonstrating the importance of ARS research on improved sensor and algorithm development to the Aerospace fields. With the continued guidance of Dr. K. Jon Ranson, the Head of NASA Goddard's Biospheric Sciences Branch and ARS Technical Monitor, synthesis with the NASA mission will be further actualized.

Attachment 1

DONALD C. RUNDQUIST

Center for Advanced Land Management Information Technologies (CALMIT)
School of Natural Resource Sciences and Conservation and Survey Division

University of Nebraska-Lincoln
113 Nebraska Hall
Lincoln, NE 68588-0517

Phone: 402/472-7536
FAX: (402) 472-4608
Email: drundquist1@unl.edu

Education

1977	Ph.D.	Geography, University of Nebraska-Lincoln
1971	M.A.	Geography, University of Nebraska at Omaha
1967	B.S.	Geography, University of Wisconsin-Whitewater

Professional Experience

1998 - present	Professor, School of Natural Resource Sciences
1986 - present	Director, Center for Advanced Land Management Information Technologies
1989 - present	Professor, Conservation and Survey Division (CSD)
1987-90	Branch Chief, Geographic Information Systems, CSD
1984-87	Program Manager, Land Resources, CSD
1982-89	Assistant and Associate Professor, CSD
1975-81	Assistant Professor of Geography and Director of Remote Sensing Applications Laboratory, University of Nebraska at Omaha

Journal Publications Since 2000

- Vina, A., Gitelson, A., Rundquist, D., Keydan, G., Leavitt, B., & Schepers, J. (2004). Monitoring maize (*zea mays* L.) phenology with remote sensing. *Agronomy Journal*.
- Rundquist, D., Perk, R., Leavitt, B., Keydan, G., & Gitelson, A. (2004). Collecting spectral data over cropland vegetation: Using machine positioning versus hand-held positioning of the sensor. *Computers and Electronics in Agriculture*.
- Vina, A., Echavarría, F., & Rundquist, D. (2004). Satellite change detection analysis of deforestation rates and patterns along the Colombia-Ecuador border. *Ambio*, 33(3), 118-125.
- Dall'Olmo, G., Gitelson, A., & Rundquist, D. (2003). From terrestrial vegetation to turbid productive waters: Toward a unified approach for remote estimation of chlorophyll-a. *Geophysical Research Letters*, 30(18), 1938-1941.
- Streck, N., Rundquist, D., & Connot, J. (2003). Spectral signatures of selected soils. *Brazilian Journal of Agrometeorology*, 11(1), 181-184.
- Gitelson, A., Vina, A., Arkebauer, T., Rundquist, D., Keydan, G., Leavitt, B., and Verma, S. (2003). Remote estimation of leaf area index and green leaf biomass in maize canopies. *Geophysical Research Letters*, 30(5), 1248-1251.
- Gitelson, A., Verma, S., Vina, A., Rundquist, D., Keydan, G., and Arkebauer, T. (2003). Technique for remote estimation of canopy CO₂ fluxes. *Geophysical Research Letters*, 30(9), 1486-1489.
- Han, L. & Rundquist, D. (2003). The spectral responses of *Ceratophyllum demersum* at varying depths in an experimental tank. *International Journal of Remote Sensing*, 24(4), 859-864.

Attachment 1 Continued

- Maeder, J., Narumalani, S., Schalles, J., Rundquist, D., Perk, R., Hutchins, K., & Keck, J. (2002). Classification and mapping of general coral-reef distribution using IKONOS data. *Photogrammetric Engineering and Remote Sensing*, 68(12), 1297-1305.
- Gitelson, A., Stark, R., Grits, U., Rundquist, D., Kaufman, Y., & Derry, D. (2002). Vegetation and soil lines in visible spectral space: A concept and technique for remote estimation of vegetation fraction. *International Journal of Remote Sensing*, 23(13), 2537-2562.
- Streck, N., Rundquist, D., and Connot, J. (2002). Estimating residual wheat dry matter from remote sensing measurements. *Photogrammetric Engineering and Remote Sensing*, 68(11), 1193-1201.
- Gitelson, A., Kaufman, Y., Stark, R., & Rundquist, D. (2002). Novel algorithms for remote estimation of vegetation fraction. *Remote Sensing of Environment*, 80, 76-87.
- Schalles, J., Rundquist, D., & Schiebe, F. (2001). The influence of suspended clays on phytoplankton reflectance signatures and the remote estimation of chlorophyll. *Verh. Internat. Verein. Limnol.*, 27, 3619-3625.
- Rundquist, D., Narumalani, S., & Narayanan, R. (2001). A review of wetlands remote sensing and defining new considerations. *Remote Sensing Reviews*, 20(3), 207-226.
- Lodhi, M. and Rundquist, D. (2001). A spectral analysis of bottom-induced variation in the colour of Sand Hills lakes, USA. *International Journal of Remote Sensing*, 22(9), 1665-1682.
- Rundquist, D. (2001). Field techniques in remote sensing: Learning by doing. *GeoCarto International*, 16(1), 83-88.
- Ullah, A., Rundquist, D., & Derry, D. (2000). Characterizing spectral signatures for three selected emergent macrophytes: A controlled experiment. *GeoCarto International*, 15(4), 29-39.
- Gosselin, D., Rundquist, D., & McFeeters, S. (2000). Remote monitoring of selected groundwater dominated lakes in the Nebraska Sand Hills. *Journal of the American Water Resources Association*, 36(5), 1039-1051.
- Stark, R., Gitelson, A., Grits, U., Rundquist, D., and Kaufman, Y. (2000). New technique for remote estimation of vegetation fraction: Principles, algorithms, and validation. *Aspects of Applied Biology*, volume 60, pp. 241-246
- Tolk, B., Han, L., and Rundquist, D. (2000). The impact of bottom brightness on spectral reflectance of suspended sediments. *International Journal of Remote Sensing*, volume 21, number 11, pp. 2259-2268
- Gitelson, A., Yacobi, Y., Schalles, J., Rundquist, D., Han, L., Stark, R., and Etzion, D. (2000). Remote estimation of phytoplankton density in productive waters. *Archives of Hydrobiology: Advances in Limnology*, volume 55, pp. 121-136

Examples of Recent Grants

1. Holz (PI), K. Hoagland, A. Gitelson, J. Merchant, D. Rundquist, and others, 2001. Lake classification in agricultural settings. EPA, \$1,200,000 over 3 years.
2. R. Narayanan (PI), D. Rundquist, and B. Bowen, 2000. Purchase of Piper Saratoga aircraft for remote sensing, NSF, \$450,000 over 1 year.
3. D. Rundquist (PI), 1999. America's Farm, NASA, \$700,000 over 3 years.
4. D. Rundquist (PI), 1998. Affiliated Research Center, NASA, \$625,000 over 3 years.
5. D. Rundquist (PI), 1997. Environmental monitoring laboratory, NASA, \$357,000 over one year.

Ph.D. Graduate Committees Supervised and Current Positions Held by Former Students

Lloyd Queen, Professor, Department of Forestry, University of Montana; Albert Peters, Research Associate Professor, CALMIT, University of Nebraska-Lincoln; Liping Di, Senior Scientist, Raytheon Corporation, Goddard Space Flight Center; Douglas Goodin, Associate Professor of Geography, Kansas State University; Luoheng Han, Associate Professor of Geography, University of Alabama; Rolland Fraser, Assistant Professor of Geography, Western Michigan University; Mahtab Lodhi, Assistant Professor of Geography, University of New Orleans; Asad Ullah, Science Systems & Applications, MD; Stuart McFeeters, GIS Specialist, University of California-Kearney; Deborah DeMarey, Chowan College.

NASA NEBRASKA EPSCoR

VALIDATED NUMERICAL MODELS
FOR THE CONVECTIVE EXTINCTION
OF FUEL DROPLETS (CEFD)

Dr. George Gogos, PI
University of Nebraska – Lincoln
Department of Mechanical Engineering
N104 WSEC
Lincoln, NE 68588-0656

(402) 472-3006 phone
(402) 472-1465 fax
ggogos@unl.edu

Cooperative Agreement #: NCC5-572

Submitted: April 30, 2004

Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Report of Progress for the

**Validated Numerical Models for the Convective Extinction of Fuel Droplets (CEFD)
Collaborative Research Team (CRT)**

I. Original Proposal Abstract

In the absence of gravity, a stationary droplet that is burning within a sufficiently weak oxidizing flow field is surrounded by a non-spherical axisymmetric envelope flame. As the velocity is increased, the characteristic flow time decreases. Eventually, a velocity is reached (called extinction velocity) that does not allow sufficient residence time for chemical reaction to take place and the flame extinguishes near the forward stagnation-point. Further velocity increase can lead to what is known as a wake flame, with the reaction occurring mostly in the rear of the droplet. The transition from an envelope to a wake flame is accompanied by a sharp decrease in the mass burning rate of the droplet. As a result, knowledge about extinction velocity and the factors that control it can be very important in spray calculations for the design of practical combustion systems.

The present state of knowledge on convective extinction of fuel droplets mostly derives from porous sphere and suspended droplet experiments conducted under normal gravity conditions. The porous sphere experiments offer the capability to vary the diameter significantly and have shown that the extinction velocity varies linearly with diameter. Due to the increase in the extinction velocity with droplet diameter, under extinction conditions, natural convection becomes negligible at large "droplet" (porous sphere) diameters and becomes important at smaller droplet diameters. As a result, any data obtained with suspended droplets under normal gravity are grossly affected by gravity. The need to obtain experimental data under microgravity conditions is therefore well justified. The Microgravity Combustion Science Program is already sponsoring a project to obtain such data. It is currently a flight definition experiment conducted by V. Nayagam, J.B. Haggard and F.A. Williams. This proposal requests funding to develop a new comprehensive numerical model for the convective extinction of fuel droplets and to validate this model. Upon an agreement with Nayagam and his co-investigators, experimental data obtained under microgravity conditions will be made available to us for model validation.

The proposed model will include the following aspects: (a) it will be transient, (b) it will allow for grid adaptation, and (c) it will employ multi-step chemical kinetics. The author of this proposal has considerable experience dealing with this particular problem and with droplet evaporation/combustion in general. In his most recent work with his doctoral student Daniel Pope (funded by the NASA EPSCoR Preparation Grant program), a robust quasi-steady axisymmetric code with one-step chemical kinetics was developed that predicts extinction velocities over a wide range of droplet diameters. The model has been validated qualitatively using normal gravity experimental data and the very limited microgravity data that are available in the literature. Using this model the present state of knowledge on the dependence of the extinction velocity on the droplet diameter has been challenged. It has been shown that the extinction velocity as a function of droplet diameter exhibits a nonlinear dependence for small diameters ($d < 1$ mm), and a linear dependence only for large diameters ($d > 2$ mm). In view of this result, and given that the experiment of Nayagam and his co-investigators will provide experimental data for large droplets (2-5 mm in diameter), it becomes imperative to develop the proposed validated model. Once validated, such a model can be used in parameter ranges

outside those of the experimental data (such as for droplets of a size typically present in sprays). Clearly, the proposed theoretical study will enhance the understanding of a well-defined flight experiment in combustion science.

Developing a code that includes all three aspects mentioned above constitutes a major challenge. The large number of dependent variables introduced by the use of multi-step chemical kinetics result in enormous computational requirements that will necessitate the use of massive parallel computing. The National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign (UIUC) will be used for most of the simulations. Success in the proposed work will depend on our considerable experience. Daniel Pope will continue working on the proposed research as post doctoral associate; his efforts and expertise will contribute immensely to the timely completion of the proposed work.

The proposed research will have a direct impact on the economic development of Nebraska. It will help us to attract external funding so that we can migrate from EPSCoR funding to other sources. The proposed research addresses one of the long-term goals of the HEDS microgravity combustion program. Integrated with the associated experiment conducted by Nayagam and co-investigators it will create the "understanding that will permit lessons learned in microgravity combustion experiment and modeling to be used in optimizing combustion devices here on Earth"[1]. For example, the validated model can be employed to simulate moving burning droplets and to provide invaluable information for spray calculations relevant in the design of practical combustion devices (such as the design of combustors for aircraft jet engines).

II. Team Accomplishments

The original CEFD 2000 proposal called for development of a comprehensive convective droplet combustion model that would: (a) be transient, (b) allow for grid adaptation, and (c) employ multistep chemical kinetics. However, discussions with CEFD Technical Monitor Dr. Vedha Nayagam and leading members of the combustion community led to a revised set of milestones. These revised milestones have been met, as can be seen from the discussion that follows. The accomplishments during the first three years are presented below.

First, the quasi-steady model was significantly improved by relaxing the assumption of a single binary diffusion coefficient and by employing chemical kinetics that are more appropriate for extinction of combusting n-heptane droplets. These two aspects are briefly discussed below.

(1) The assumption of a single binary diffusion coefficient (along with neglecting pressure and thermal diffusion) results in Fick's Law for the diffusion velocity of each species. The binary diffusion coefficient for the fuel and oxidizer was used in the quasi-steady code and was evaluated as a function of the local temperature. Due to this assumption, the numerical predictions were only in qualitative agreement with experimental results from the literature. The new code employs the Stefan-Maxwell equations to allow for different multicomponent diffusion coefficients. This newly developed multicomponent formulation will impact the numerical simulation of combustion problems beyond droplet combustion. It is appropriate for use with the finite-volume method and can accurately describe diffusion velocities.

(2) We incorporated into the quasi-steady model the more appropriate chemical kinetics of Seiser et al. [1] in place of the chemical kinetics of Westbrook and Dryer [2]. All previous simulations were repeated and results were presented in the International Conference on Power Engineering, in November 2003, in Kobe, Japan.

In addition to the above improvements, an important correlation for the conditions of extinction has been developed (Damkohler versus Reynolds numbers). Two refereed journal

papers and a refereed conference paper are near completion to be submitted. A transient numerical model has been developed. This new code incorporated the multicomponent species formulation and the chemical kinetics of Seiser et al. [1] that were discussed above. Three important aspects have been investigated as a result of our collaboration with the NASA Technical Monitor. These aspects enable simulation of experiments conducted by Dr. Nayagam and co-workers under microgravity conditions (ground-based, Space Shuttle and International Space Station). These three aspects are discussed below.

(1) Suspended versus moving droplets. This study addresses the difference in combustion behavior, given the same initial conditions, of an isolated liquid fuel droplet under two scenarios: moving droplet and suspended droplet combustion in a forced convection environment. The first simulates the injection of a droplet into a combustion chamber, where the droplet is allowed to decelerate due to the drag force. The second simulates the conditions that are typically present in experiments that employ the suspended droplet technique (constant velocity). The transient numerical model was used to simulate the two cases. This work was presented at conferences and a paper will be submitted to a refereed journal. In March 2003, Dr. Nayagam's experiment, a candidate for a flight experiment in the International Space Station, underwent a review by an external committee. Since the CEFD results are extremely relevant to Dr. Nayagam's research effort, for the second time (the first time was during a NASA internal review) Dr. Nayagam connected with our website and presented CEFD results during the external review.

(2) Simulation of methanol droplets. Dr. Nayagam conducts experiments both with n-heptane and methanol droplets. Our axisymmetric transient code was developed for n-heptane droplets. We agreed to develop a numerical model for methanol droplet simulations.

(3) Axisymmetric transient code for low ambient temperatures. Our axisymmetric transient code was developed for droplets that self-ignite at high ambient temperatures. Since Dr. Nayagam's experiments are conducted at low ambient temperatures, we also agreed to incorporate into our numerical model droplet ignition at low ambient temperatures.

Halfway through Year 2 and after strong encouragement from Dr. Nayagam, we pursued the rapid development of an axisymmetric transient code that will enable methanol droplet combustion instead of completing Year 2 proposed components "Chemical Kinetics Models" and "Grid Adaptation." We chose to accept Dr. Nayagam's recommendations to schedule such objectives for future research beyond Year 3 after completing i) methanol droplet simulations, ii) low ambient temperature ignition and iii) radiation. As of March 2004, items i) and ii) have been completed. We are presently conducting our initial methanol droplet simulations. Radiation will be considered during the summer of 2004.

A final note: When Dr. Gogos attended the March 2003 Annual NASA EPSCoR conference in Washington, DC, he met with Dr. Roger Crouch, NASA chief scientist for the International Space Station. Dr. Crouch spent a great deal of time reviewing the CEFD poster. Dr. Crouch's interest was peaked so greatly that Dr. Gogos elected to show him a number of videos produced from CEFD simulations. During this informal meeting, it was discovered that Dr. Crouch had conducted Dr. Nayagam's (CEFD CRT Technical Monitor) preliminary combustion experiment aboard the Columbia Space Shuttle in 1997. Since the CEFD model simulates Nayagam's experiment, this CRT's results were familiar territory to him. Dr. Crouch's reaction to our work was, "Is this done with EPSCoR money?" This is a tribute to the innovative and highly relevant research being conducted by Dr. Gogos' team in Nebraska through NASA EPSCoR funding.

III. CEFD Articles Submitted to and/or Published in Refereed Journals

1. Pope, D. N., & Gogos G. (in preparation). A new multicomponent diffusion formulation for the finite-volume method. *Numerical Heat Transfer*.
2. Pope, D. N., & Gogos, G. (in preparation). Numerical simulation of n-Heptane droplet extinction due to forced convection. *Combustion and Flame*.
3. Pope, D. N., Howard, D., Lu, K., & Gogos, G. (in preparation). Combustion of moving droplets and of droplets suspended within a convective environment: Transient numerical results.
4. Gogos, G., & Zhang, H. (in preparation). Droplet evaporation within a zero gravity high pressure and high temperature environment. Part II. Low Weber number relative motion. *International Journal of Heat and Mass Transfer*.
5. Gogos, G., & Zhang, H. (in preparation). Droplet evaporation within a zero gravity high pressure and high temperature environment. Part I. No relative motion. *International Journal of Heat and Mass Transfer*.
6. Gogos, G., Soh, S., & Pope, D. N. (2003). Effects of gravity and ambient pressure on liquid fuel droplet evaporation. *International Journal of Heat and Mass Transfer*, 46, 283-296.
7. Zhang, H., & Gogos, G. (2004). Numerical research on a vaporizing fuel droplet in a forced convective environment. *International Journal of Multiphase Flow*, 30, 181-198.

IV. List of Patents Pursued by the CEFD CRT

No patents have been pursued by the CEFD CRT.

V. Participation in Professional Events

1. Pope, D.N., & Gogos, G. (2004, November 14). *A new multicomponent diffusion formulation for the finite-volume method*. Research to be presented at the Annual International Mechanical Engineering Congress and Exposition: Anaheim, CA.
2. Pope, D.N., & Gogos, G. (2003, November 9-13). *Numerical simulation of fuel droplet extinction during forced convection*. Research presented at the Annual International Conference on Power Engineering.
3. Zhang, H., and Gogos, G. (2001, October 8-12). Droplet evaporation within a zero gravity high pressure and high temperature convective environment. *Proceedings of the International Conference on Power Engineering*: Xi'an, China.
4. Howard, D., Pope, D.N., & Gogos, G. (2004, April 16). Modeling combustion of moving methanol droplets. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE.
5. Pope, D.N., & Gogos, G. (2004, April 16). A new multicomponent diffusion formulation for the finite-volume method. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE.
6. Gogos, G., & Pope, D.N. (2003, June 3-6). *Combustion of moving droplets and of droplets suspended within a convective environment: Transient numerical results*. Research presented at the 7th Annual International Workshop on Microgravity Combustion and Chemically Reacting Systems: Cleveland, OH.
7. Zhang, H., Shi, Y., & Gogos, G. (2003, April 25). The evaporation and deformation of a moving fuel droplet in a high pressure combustion chamber. *Proceedings of the 123rd Annual Nebraska Academy of Sciences*: Lincoln, NE.

8. Pope, D.N., Lu, K., & Gogos, G. (2003, April 25). Combustion of moving droplets and of droplets suspended within a convective environment: Transient numerical results. *Proceedings of the 123rd Annual Nebraska Academy of Sciences*: Lincoln, NE.
9. Pope, D.N., Lu, K., & Gogos, G. (2003, March 16-19). *Combustion of moving droplets and of droplets suspended within a convective environment: Transient numerical results*. Research presented at the Third Joint Meeting of the U.S. Sections of The Combustion Institute: Chicago, IL.
10. Gogos, G., Pope, D.N., & Lu, K. (2003, March 16-18). *Validated numerical models for the convective extinction of fuel droplets*. Research presented at the NASA EPSCoR Annual Conference: Arlington, VA.
11. Zhang, H., Shi, Y., & Gogos, G. (2002, April 26). Evaporation of a deformable fuel droplet under a forced convective environment. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE.
12. Lu, K., Pope, D.N., & Gogos, G. (2002, April 26). Numerical simulation of suspended and moving droplet combustion. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE.
13. Gogos, G. (2002, November 8). *Sub- and super-critical evaporation and combustion of moving fuel droplets*. Research presented at the Chemical Engineering Seminar Series, University of Nebraska-Lincoln: Lincoln, NE.

VI. Follow-on Grant Proposals Submitted and Funded

During the course of the project, CEFD researchers pursued substantial funding beyond that which was provided by NASA EPSCoR. These grants involved or are involving various Nebraska researchers. Seven grants were pursued. Four were awarded and three were not funded. In total, the CEFD CRT has secured an additional \$350,000 in non-NASA research funding, with the possibility of securing a total of \$1,791,998.

Three grants were successfully obtained through the Department of Defense for utilization of funding from June 1, 2004 to May 31, 2005. Dr. Gogos led the preparation of these three proposals, which are titled: (1) "Development of Novel Blast Wave Absorbing Structures: An Experimental and Modeling Program – Awarded in the amount of \$75,000; (2) "Thin Film $Ba_{1-x}Sr_xTiO_3$ on Cost Effective Substrates: A Modeling, Simulation and Experimental Program – Awarded in the amount of \$200,000; and (3) "Vortex Tube Based Portable PCR for Rapid Pathogen Detection – Awarded in the amount of \$75,000.

Dr. Gogos also led the preparation of a proposal to the National Institutes of Health (NIH) titled, "Vortex-tubed Based Thermocycler with Intelligent Software." This proposal was submitted in October 2003 and was awarded in April 2004, providing the CEFD CRT with an additional \$1,441,998. This proposal, which provides funding for a 5-year time period, received a NIH priority score of 137. The NIH scale is from 100 to 500, with 100 corresponding to perfect score.

In the summer of 2003, a proposal was submitted to the Department of Homeland Security. Although not funded, this award would have provided \$27,600 for the institution of a Graduate Assistantship for graduate student Ryan Ebmeier, CEFD researcher. One other unsuccessful proposal was titled "K.P. Performance Enhancement of Process Technology in Rotational Molding." This grant was offered by Casting Techniques, etc. by Ultrasound and submitted as a White Paper to NSF.

VII. Confirmation of Technical Monitor Contact and Involvement

CEFD research is conducted in close consultation with the NASA Technical Monitor, Dr. Vedha Nayagam (appointed by Dr. David L. Urban, the NASA Technical Monitor in the original proposal). Although no record of all communications has been kept, a list of the major meetings that defined the path (revised milestones) of the conducted research is presented below:

1. Technical Meeting of the Central States Section of the Combustion Institute, April 16-18, 2000, Indianapolis, IN.
2. Numerous communications (phone and e-mail) during April of 2002.
3. Numerous communications (phone and e-mail) during Fall 2002 and early 2003.
4. Third Joint Meeting of the U.S. Sections of the Combustion Institute, Chicago, IL, March 16-19, 2003.
5. Dr. Vedha Nayagam visited CEFD facilities during April 17-18, 2003.
6. 7th International Workshop on Microgravity Combustion and Chemically Reacting Systems, Cleveland, OH, June 3-6, 2003.
7. Numerous communications (phone and e-mail) during April of 2003.
8. Numerous communications (phone and e-mail) during August 2003.

Dr. Nayagam has provided confirmation of his support of CEFD CRT research progress during the first three years of funding. Specifically, Dr. Nayagam provided notification of his review and approval of the CEFD Year 2 Report, Year 3 Proposal, the above CEFD Research Area Award Report of Progress, and the following CEFD Research Area Award Request for Continuation.

VIII. CEFD Personnel Information

CEFD CRT member	Male	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty	3		1		2	
Post-Doctoral						
Staff	1		1			
Graduate Student	4		1		3	
Undergraduate Student						

IX. Progress Toward Achieving Self-sufficiency Beyond Award Period

CEFD Principal Investigator Gogos has successfully secured substantial non-NASA funding. This success indicates that similar success can be expected in the years to come. New projects, driven by initial research achievement, now drive proposed work for Years 4 and 5. The same techniques can be employed in droplet combustion under different conditions of interest such as elevated pressures that prevail in high performance aircraft combustors. Dr. Gogos's plans for securing additional funding for continuing the CEFD mission are described in greater detail in the CEFD Request for Continuation.

X. Research Results

The major accomplishments of the CEFD project during the first three years of funding are as follows: (A) a new multicomponent formulation, that is appropriate for use with the finite-volume method, was developed; (B) the chemical kinetics of Westbrook and Dryer [2] was replaced with the more appropriate kinetics of Seiser et al. [1]; (C) the quasi-steady droplet combustion model was modified to include items (A) and (B), and was used to numerically investigate n-heptane droplet extinction; (D) a new transient droplet combustion model, which

included items (A) and (B), was developed and a study of the difference between suspended and moving droplet combustion was conducted; (E) low ambient temperature ignition was incorporated in the transient code; and (F) the transient code was modified to simulate the combustion of methanol droplets. Each of these accomplishments is addressed in detail below.

A. New Multicomponent Formulation

The original formulation for mass diffusion was based on the assumption of a single binary diffusion coefficient for all species, along with neglecting pressure and thermal diffusion, which results in Fick's Law for the diffusion velocity of each species. The new formulation [3] utilizes the Stefan-Maxwell equations and includes thermal diffusion. These equations are combined with the species conservation equation and placed in a form that is appropriate for use with the finite-volume method. This newly developed multicomponent formulation will have an impact on numerical simulation of combustion problems beyond droplet combustion.

B. Chemical Kinetics

The chemical kinetics parameters of Westbrook and Dryer [1] are based on premixed laminar flame speed data. A diffusion-flame forms around a fuel droplet. The chemical kinetics parameters for n-heptane were replaced with the values from Seiser et al. [2]. They used experimental data for diffusion-flames to determine their kinetics parameters.

C. Quasi-steady Results

The quasi-steady code has been used to predict extinction velocities ($U_{\infty,e}$) for n-heptane droplets burning in air at atmospheric pressure and under zero-gravity conditions [4]. Table 1 shows the ambient temperatures (T_{∞}) and droplet diameters (d) considered. Experimental results available in the literature for various fuels and different droplet diameters and ambient temperatures compare well with the numerical predictions for n-heptane. A linear dependence of the extinction velocity as a function of droplet diameter constitutes the present state of knowledge. Our predictions show a nonlinear dependence for small diameters ($d < 1$ mm) and a linear dependence for large diameters ($d > 2$ mm).

The asymptotic results of Krishnamurthy et al. [5] for diffusion-flame extinction in a stagnation-point boundary layer suggest that the Damköhler number should scale with the adiabatic flame temperature (T_{ad}), the activation temperature and the transfer number (B). Figure 1 (below) shows a plot of $Da_{M,e}(T_f^* \epsilon)^3(1+B)$ vs. $Re_{M,e}$ for all of the cases shown in Table 1. The Damköhler ($Da_{M,e}$) and Reynolds ($Re_{M,e}$) numbers at extinction are defined as

$$Da_{M,e} = \frac{AR}{U_{\infty,e}} \rho_M \frac{1}{W_o} \exp\left[\frac{-E_a}{R_u T_{ad}}\right] \quad \text{and} \quad Re_{M,e} = \frac{dU_{\infty,e}}{\nu_M}$$

Table 1: Ambient temperatures and droplet diameters used for quasi-steady numerical results.

T_{∞} (K)	d (mm)
300	0.1, 0.15, 0.2, 0.3, 0.5, 0.6, 0.8, 1, 1.3, 2, 3, 4.5, 6, 8, 15
650	0.1, 0.3, 0.5, 1, 2, 3, 4.5, 6, 8
673	0.1, 0.3, 0.5, 1, 2, 3, 4.5, 6, 8
800	0.1, 0.3, 0.5
1000	0.1, 0.3, 0.5, 1, 2, 3, 4.5, 6, 8
1140	0.1, 0.3, 0.5, 1, 2, 3, 4.5, 6, 8
1200	0.1, 0.3, 0.5
1400	0.1, 0.3, 0.5

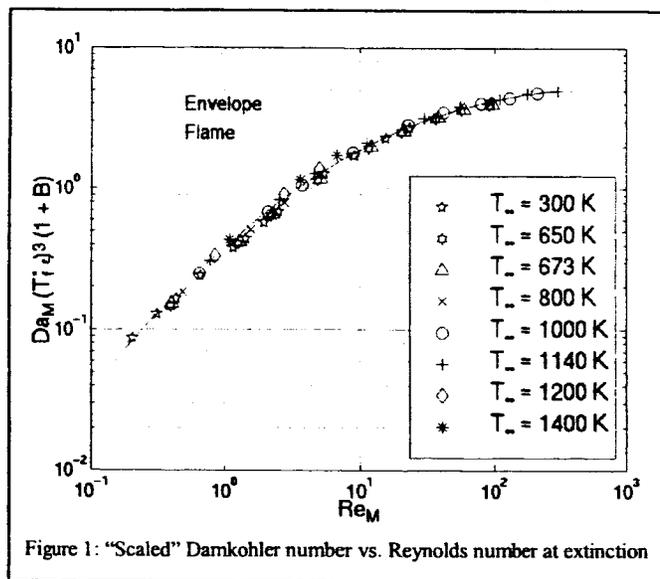


Figure 1: "Scaled" Damkohler number vs. Reynolds number at extinction

where ν is the kinematic viscosity, A is the pre-exponential factor, R is the droplet radius, ρ is the density W_o is the molecular weight of oxygen, E_a is the activation energy, R_u is the universal gas constant and the subscript "M" indicates that the properties are evaluated using the ambient composition (dry air) and a mean temperature of $T_M = 0.5(T_{ad} + T_\infty)$. The dimensionless flame temperature (T_f^*), activation temperature (ϵ) and transfer number are defined by

$$T_f^* = \frac{T_{ad} \bar{c}_{p,f}}{Q}, \quad \epsilon = \frac{T_{ad} R_u}{E_a} \quad \text{and} \quad B = \frac{Q\sigma + \bar{c}_{p,f}(T_\infty - \bar{T}_s)}{L}$$

where Q and L are the lower heating value and latent heat of vaporization of the fuel, σ is the stoichiometric fuel to oxidizer (including inert species) mass ratio, \bar{T}_s is the average droplet surface temperature and $\bar{c}_{p,f}$ is the specific heat capacity of the fuel evaluated at $\bar{T} = 0.5(T_{ad} + \bar{T}_s)$. Figure 1 shows that the numerical results collapse onto a single curve. The figure also shows a correlation (solid line) of the form, where

$$Da_{M,e} (T_f^* \epsilon)^3 (1 + B) = (0.377 + 1.95 \times 10^{-3} \text{Re}_{M,e}) \text{Re}_{M,e}^2$$

$$Z = 0.846 - 0.155 w - 1.28 \times 10^{-2} w^2 - 6.35 \times 10^{-3} w^3$$

and $w = \log_{10} \text{Re}_{M,e}$. The correlation predicts extinction velocities over the range $0.15 < \text{Re}_{M,e} < 400$ that are in good agreement with the numerical results for n-heptane droplets in air at atmospheric pressure. Correlations of the type just presented are necessary components for spray combustion models.

D. Transient Results

The transient numerical model was used to investigate the combustion of a n-heptane droplet with an initial diameter of 500 μm [6]. The study addresses the difference in combustion behavior, given the same initial conditions, of an isolated liquid fuel droplet under two scenarios: a) moving droplet and b) suspended droplet combustion in a forced convection environment. The results presented here are for $T_\infty = 1200$ K, an ambient pressure (P_∞) of 1 atm, an initial droplet temperature (T_0) of 297 K and initial Reynolds numbers (Re_0) of 10, 12 and 50.

Table 2 compares the lifetimes (t_d) of both moving and suspended n-heptane droplets for the Reynolds numbers considered. The table contains interesting results that need to be explained. For example, the lifetime of a moving droplet with $\text{Re}_0 = 50$ is longer than the lifetimes of moving droplets with initial Reynolds numbers of 10 and 12. Furthermore, for the same initial Reynolds number, the suspended droplet burns out faster than its moving droplet counterpart in two cases ($\text{Re}_0 = 10, 50$), while for $\text{Re}_0 = 12$, the result is the opposite.

$P_\infty = 1 \text{ atm}$ $T_\infty = 1200 \text{ K}$ $T_0 = 297 \text{ K}$ $d_0 = 500 \mu\text{m}$	$\text{Re}_0 = 10$	Suspended	$t_d = 198 \text{ ms}$
		Moving	$t_d = 220 \text{ ms}$
	$\text{Re}_0 = 12$	Suspended	$t_d = 237 \text{ ms}$
		Moving	$t_d = 217 \text{ ms}$
	$\text{Re}_0 = 50$	Suspended	$t_d = 187 \text{ ms}$
		Moving	$t_d = 229 \text{ ms}$

Table 2: n-heptane droplet lifetimes for suspended and moving droplets

Figure 2 (below) shows the time history of the (a) dimensionless droplet diameter squared (d/d_0)², (b) ratio of instantaneous to initial Reynolds numbers (Re/Re_0), (c) Damköhler

number and (d) evaporation constant (K) for suspended (dashed lines) and moving (solid lines) droplets at $Re_0 = 10$ and 50.

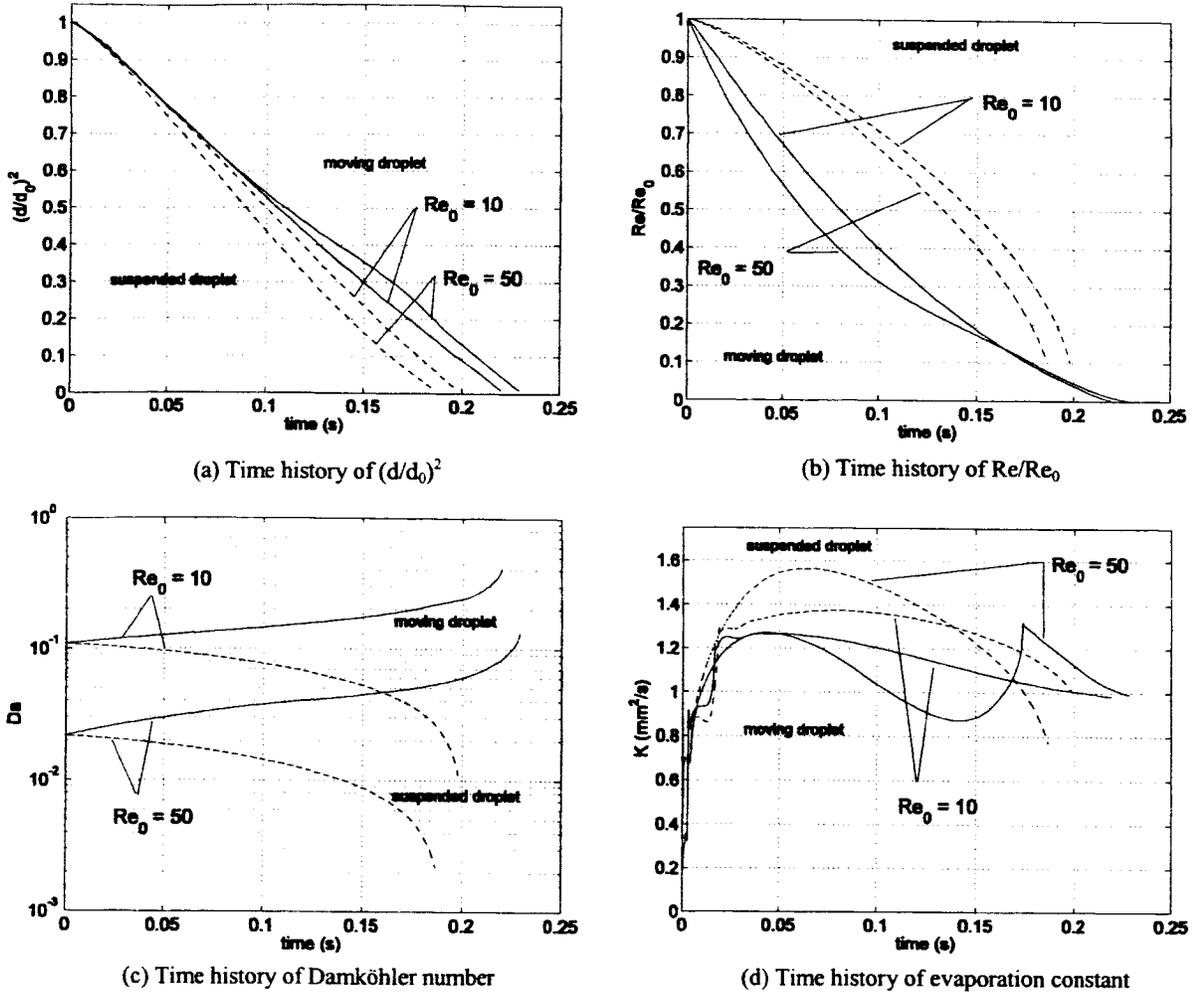


Figure 2: Comparison between moving droplet and suspended droplet combustion for $Re_0 = 10$ and $Re_0 = 50$ ($d_0 = 500 \mu\text{m}$ and $T_\infty = 1200 \text{ K}$).

For $Re_0 = 10$, the suspended and moving droplets develop envelope flames at approximately the same time ($t = 20 \text{ ms}$). Once the envelope flame formed, it remained for both droplets until the end of their lifetimes. Thus, during most of the droplet lifetime, both the suspended and the moving droplet experience the same flame configuration. This implies that the two droplets will exhibit similar burning behavior and thus similar lifetimes. Figure 2(a) shows that to be true. The droplets in both cases have very similar diameter squared time histories. Figure 2(b) shows the time history of the instantaneous Reynolds numbers for a suspended and moving droplet with $Re_0 = 10$. Both Reynolds numbers decrease monotonically with time, however they decrease at different rates. The Reynolds number is defined as $Re = d(t)U_\infty(t)/\nu_\infty$ where $d(t)$ and $U_\infty(t)$ are the instantaneous droplet diameter and freestream velocity. The freestream velocity remains constant for the suspended droplet. As a result the Reynolds number changes only with the droplet diameter. However, for the moving droplet, the droplet diameter decreases and the droplet velocity decreases due to drag. Thus the Reynolds number for the moving droplet decreases faster than that for the suspended droplet. The higher Reynolds number associated with the suspended droplet implies a stronger convection. This results in a

higher evaporation constant for the suspended droplet than for the moving droplet as shown in Figure 2(d). The Damköhler number is proportional to the ratio of the droplet diameter to the instantaneous freestream velocity ($Da \propto d(t)/U_\infty(t)$). Figure 2(c) shows that the Damköhler number for the suspended droplet decreases with time, while for the moving droplet case, it increases slowly with time. The former result is expected since for the suspended case, U_∞ is constant while the droplet diameter decreases. This results in a monotonic decrease in Da . For the moving droplet case, the droplet velocity decreases slightly faster than the droplet diameter resulting in an increase in Da .

The results for $Re_0 = 50$ shown in Figure 2 are similar to those for $Re_0 = 10$. With this higher initial Reynolds number, both droplets ignite in the wake areas far downstream. After ignition, for the moving droplet case, the flame moves toward the droplet, and finally forms an envelope flame (at approximately $t = 174$ ms) near the end of its lifetime. For the suspended droplet, no envelope flame is developed throughout its lifetime, and the wake flame remains at approximately the same location for most of the droplet's lifetime. At $t = 155$ ms the wake flame trailing the suspended droplet extinguishes. The evaporation constant for the suspended droplet is higher than that for the moving droplet during most of the droplet lifetime as shown in Figure 2(d). This causes a much shorter droplet lifetime for the suspended droplet than the moving droplet. The steep increase in the evaporation constant for the moving droplet near the end of its lifetime is due to the formation of an envelope flame. The envelope flame at the very end of the moving droplet's life does not have an impact on its lifetime. In the absence of envelope flames, the difference in Reynolds number histories between the two cases is the only cause for their different vaporization rates. The trend in Damköhler number is the same for $Re_0 = 10$ and $Re_0 = 50$.

The combustion behavior for the two cases at $Re_0 = 12$ (not shown) is quite different from the cases discussed above. Although the Reynolds number for the suspended droplet is again higher than that for the moving droplet throughout the droplet lifetime, the lifetime of the suspended droplet is approximately 10% longer than that of the moving droplet (Table 2). The evaporation constant for the moving droplet is higher than that for the suspended case during most of the droplet lifetime, despite the fact that the suspended droplet experiences stronger convection than its counterpart. The difference in droplet lifetimes is caused by the difference in flame configurations. The moving droplet develops an envelope flame at an early stage ($t = 30$ ms) of its lifetime. In contrast, the suspended droplet exhibits a transition flame during most of the droplet lifetime. The Damköhler number follows the same trend noted for the other initial Reynolds numbers.

The results presented above can be summarized as follows. The flame configurations present in a burning droplet are a function of the time histories of both the Reynolds number and the Damköhler number. For a moving droplet, the Reynolds number decreases with time (due to both relative velocity and droplet size reduction) but the Damköhler number increases with time. For a suspended droplet, both the Reynolds number and the Damköhler number decrease with time due to the reduction in droplet size. As a result, for the same initial Reynolds number, suspended droplets may demonstrate different burning behavior than moving droplets. Within the range of initial Reynolds numbers considered ($Re_0 = 10, 12, 50$), a moving droplet tends to develop an envelope flame at some stage during its lifetime, whereas a suspended droplet develops an envelope flame only for low initial Reynolds numbers. The flame configurations present during droplet burning are critical in determining the droplet lifetime.

E. Low Ambient Temperature Ignition

In many experimental studies of droplet combustion, the droplet is ignited through the use of an external ignition source (e.g. spark). To simulate this, the transient code is run for a few time-steps so that a vapor/air mixture builds up around the droplet. Energy is then added to an axisymmetric region upstream of the droplet via the source term in the conservation of energy equation. The addition of energy occurs over several time-steps and is terminated when ignition takes place. Thus, a minimum amount of energy is introduced to cause ignition. This procedure has been utilized in the validation of the transient model against experimental data for droplet combustion at low ambient temperatures.

F. Methanol Droplet Combustion

The interface equations, liquid-phase governing equations, property correlations and chemical kinetics in the unsteady axisymmetric code have been modified to simulate the combustion of methanol droplets. The assumption of a single-component liquid fuel with negligible solubility of gas-phase species into the liquid-phase, which was used for n-heptane droplet combustion, has been removed. In methanol droplet combustion, water vapor formed by combustion dissolves into the droplet, mixes with the liquid methanol, and may revaporize. The result is a binary methanol-water system in the liquid-phase.

The interface and liquid-phase governing equations have been reformulated to accommodate mass transfer into the droplet. The conservation of species and energy equations at the interface were modified. Phase equilibrium is assumed at the droplet surface. Vapor pressure/fugacity relationships are used to calculate water and methanol mass fractions at the interface. The conservation of species equation was incorporated in the liquid-phase to model the binary methanol-water system. The liquid-phase energy equation was also modified.

Property correlations were changed in the gas-phase and liquid-phase. For methanol vapor, the viscosity and thermal conductivity are calculated using the methods recommended by Reid et al. [7] and the specific heat capacity and enthalpy are evaluated using the curvefits of McBride et al. [8]. The liquid-phase properties have been reformulated for a binary mixture of methanol and water. The pure component liquid-phase viscosities are evaluated using the curvefits given by Reid et al. [7], which are then used to calculate the mixture viscosity using the combining rules of Teja and Rice [9]. Latent heat of vaporization, density and thermal conductivity are evaluated according to the recommendations of Reid et al. [7]. The specific heat capacity of the binary mixture is calculated from pure component correlations and mixing rules supplied by Teja [10]. The gas- and liquid-phase property correlations have been validated using data provided by Vargaftik et al. [11]. Binary diffusion coefficients are required in the solution of the liquid-phase conservation of species equation. The UNIFAC method of calculating activity coefficients was used to correlate the binary diffusion coefficients. The correlation was validated against the experimental data of Lee and Li [12]. The Wilson correlation [7] provides an excellent fit of the experimental data of Kurihara et al. [13] for activity coefficients. The resulting coefficients are used in the interface vapor pressure/fugacity equations. Testing of the above changes has been completed. Initial simulations using the one-step-overall kinetics of Westbrook and Dryer [2] for methanol are currently underway.

Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Request for Continuation for the

**Validated Numerical Models for the Convective Extinction of Fuel Droplets (CEFD)
Collaborative Research Team (CRT)**

I. Two-Year Program Plan and Budget

This proposal requests funding to develop a detailed numerical model of droplet extinction in convective flows. The discussion that follows focuses on key aspects of the problem, including (1) the theoretical model, (2) available chemical kinetics models for large hydrocarbon combustion, (3) the need for an adaptive grid scheme, and (4) employing numerical methods. The CEFD CRT's plans for education outreach and technology transfer are also offered.

Results obtained from the proposed Validated Numerical Models for the Convective Extinction of Fuel Droplets (CEFD) Year 4 and Year 5 research will be documented in forms suitable for engineering applications. For example, droplet extinction velocities are recognized to be of fundamental value to engineering application. Where possible, the CEFD CRT will develop correlation equations for describing important quantities.

One faculty, one post doctoral research associate, and many graduate students will conduct the proposed research work. Dr. Daniel Pope, who has been a valuable co-worker as Dr. Gogos' doctoral student, post doctorate staff member, and most recently as Research Assistant Professor, will continue working on this project. His involvement could be his final step in pursuing his aspiration for a long-term career in microgravity research as an employee of NASA or a major research university.

The proposed research will be conducted in tandem with the experimental work of Nayagam, Haggard and Williams (hereafter referred to as the Associated Experiment). The new code that this CRT will develop will: a) allow for grid adaptation (our current model employs a variable grid both in the liquid- and in the gas-phase adjacent to the droplet interface as well as in the wake of the droplet); and b) include multi-step chemical kinetics. Upon the request of Dr. Nayagam (NASA Technical Monitor), both n-heptane and methanol combusting droplets will be simulated. Experiments conducted by Dr. Nayagam and co-workers involve both fuels.

The computational requirements to implement the above aspects are enormous and will require massive parallel computing. The National Center for Supercomputing Applications (NCSA) at UIUC will be used to conduct simulations. In addition, a UNL Research Computing Facility with quite extensive parallel computing capabilities is also available to us. This facility has the same architecture as the NCSA facility offering an extremely valuable compatibility. Developing a code that includes both grid adaptation and multi-step chemical kinetics constitutes a major challenge in the proposed work. Planned steps to meet this challenge are presented in detail below.

A. Theoretical Model

A single component liquid fuel droplet of initial radius R_0 and temperature T_0 undergoes evaporation and combustion in a convective, low pressure, zero-gravity environment of infinite expanse. The ambient pressure (P_∞) and temperature (T_∞) are constant. In practical combustion systems, the droplet is injected into an oxidant environment and decelerates due to the drag force

it experiences, which causes the freestream velocity (U_∞) relative to the droplet to vary with time. In the Associated Experiment, in some cases the ambient gas is "blown" toward the fiber-supported droplet at a fixed velocity, resulting in a U_∞ that is invariant with time, and in some cases U_∞ is allowed to be variable. Both in practical combustion systems and the Associated Experiment, shear stresses acting on the droplet liquid/gas interface cause liquid-phase internal circulation, and the droplet radius decreases due to evaporation of the fuel. Based on the freestream velocity and droplet radius, the following combustion regimes are expected: envelope flame, transition flame, wake flame, and pure vaporization. Convective extinction occurs when the flame extinguishes near the forward stagnation point of the droplet, signaling a change from an envelope flame to a different combustion regime.

The convective extinction of the droplet will be investigated thoroughly by solving the time-dependent conservation equations for mass, momentum, species, and energy in the gas-phase. At low pressures, solubility of gas-phase inert species into the liquid-phase is assumed negligible for the n-heptane case. This assumption (coupled with the assumption of a single component fuel droplet) removes the need to solve the conservation of species equation in the liquid-phase for the n-heptane case. Therefore, the liquid-phase will be described by the time-dependent conservation equations for mass, momentum, and energy. For a methanol droplet, water vapor formed by combustion dissolves into the droplet, mixes with the liquid methanol, and may reevaporize. Therefore, interface equations, liquid-phase governing equations, property correlation, and chemical kinetics are modified to simulate combustion of methanol droplets. The following additional assumptions will be adopted for both fuels: (1) the droplet maintains a spherical shape; (2) second order effects (Dufour and pressure diffusion) are negligible; (3) viscous dissipation and pressure work are negligible; and (4) body forces are negligible.

The flow field in the gas-phase will be considered axisymmetric. The droplets in the Associated Experiment are held in place by a fiber. The effect of the fiber on the experimental results will be examined. Specifically, the heat transfer from the fiber to the droplet will be included in the model. Since the imposed convective flow field is in the direction of the fiber, the flow field remains axisymmetric even in the presence of the fiber.

Gas-phase radiation measurements of axisymmetric flame configurations for n-heptane and methanol droplets burning in a slow convective flow field were recently obtained by Hicks, Kaib, Easton, Nayagam and Williams [1]. Results show that for the sizes of droplets considered (0.8 mm to 3.4 mm) radiation losses are important. Furthermore, radiation losses are expected to be more important for the even larger droplets that will be considered in the flight experiment.

The formulation of the problem will ignore soot. The literature has shown [2-4] that in spherically symmetric droplet combustion soot particles form a "spherical shell" between the droplet surface and the flame zone. The shell's location is defined by the balance between two forces acting on the soot particles (namely, the radially inward thermophoretic force and the radially outward force exerted by the evaporation-induced flow field). This shell acts as a radiation shield and may have a significant effect on the rate of droplet burning in spherically symmetric droplet combustion [5]. In the presence of convection, both the temperature field and the flow field are two dimensional (actually axisymmetric). The two forces acting on precursors to soot particles are no longer radial. In addition, the two forces do not in general act in opposite directions. As a result, these precursors are not expected to move towards an equilibrium position. The soot "shell" under such conditions "is like a particle trajectory along which soot aggregates move in response to forces acting on them" [6]. This has been clearly shown in the literature [7]. The convective motion carries the soot precursors and particles to the flame region

in the downstream direction where oxidation takes place before the particles can grow to appreciable size. Randolph and Law [7] have shown that even a weak convection that has almost no influence on fuel oxidation (as evidenced by the near sphericity of the flame) transports continuously the soot precursors to the rear region. There is a luminous flame zone, characteristic of the presence of soot radiation, only towards the rear of the droplet. The rest of the flame is blue--even for the case of phenyldodecane, which is quite sooty. The extinction velocity increases monotonically with the droplet diameter. As a result, at extinction conditions, the larger the droplet diameter the stronger the convective field. For 2-5 mm diameter droplets, based on ambient conditions, the Reynolds number at extinction ranges from about 60-230 [8]. In view of the above discussion, it is hypothesized that the effect of soot on convective droplet extinction is negligible. This hypothesis can actually be tested by comparing experimental data with model predictions over a wide range of strength of the convective field. Predictions should deviate from the experimental data increasingly as spherically symmetric conditions are approached.

Gas-phase radiation will be included in the model following Marchese, Dryer, and Nayagam [9]. Thermal radiation losses in the gas-phase result entirely from nonluminous emission associated with carbon monoxide, carbon dioxide and water. The effect of gas-phase radiation can be handled with a small increase in computational requirements [9]. Alternatively, the radiation treatments employed by Tien and coworkers [10,11] where carbon dioxide and water vapor were considered emitting and absorbing radiation in discrete bands (nongray gases) will also be considered.

The resulting axisymmetric governing equations with single-step chemical kinetics have been solved numerically by the author, and results have been presented in [8,12,13]. These equations are omitted here for the sake of brevity. Gas-phase radiation will be included in the model following Marchese, Dryer, and Nayagam [9]. Thermal radiation losses in the gas-phase result entirely from nonluminous emission associated with carbon monoxide, carbon dioxide and water. The effect of gas-phase radiation can be handled with a small increase in computational requirements [9].

B. Chemical Kinetics Models

Finite-rate chemical kinetics models for large hydrocarbon combustion range from global kinetics using a one-step overall chemical reaction [14] to detailed mechanisms with hundreds of reactions and chemical species [15-17]. For numerical models, the trade-off for an increased level of detail in the chemical kinetics is an increase in cpu time and computer memory requirements. Each additional species included in the model requires the solution of an additional conservation of species equation at each node and storage for the species mass fraction at each nodal point. An increase in the number of chemical reactions requires additional computations, which results in an increase in the cpu time. As a result, axisymmetric numerical models for large hydrocarbon combustion have been limited to the use of global kinetics.

The CEFD CRT intends to incorporate semi-detailed kinetics in a two-dimensional model of combustion of a moving droplet in a low pressure environment. Semi-detailed mechanisms for large hydrocarbons have been used in one-dimensional numerical models for droplet combustion [9,18]. Use of these mechanisms in a two-dimensional model will require adaptive grid and parallel computing techniques to obtain accurate solutions within a reasonable time while minimizing memory requirements. Several mechanisms already available for use in the proposed model [19-21] will allow for an appropriate model or models to be selected based on validation with experimental results.

Grid Adaptation

In general, adaptive schemes attempt to couple the location of grid points to the physics of the problem, resulting in a concentration of grid points in regions where the dependent variable changes rapidly [22]. The goal of utilizing an adaptive grid system is to obtain accurate numerical solutions with a minimum number of grid points. The decrease in number of grid points reduces the memory usage and cpu time which makes solution of more complex problems possible. This is a requirement for the present two-dimensional problem due to the large number of dependent variables introduced when using semi-detailed or detailed chemical kinetics.

Incorporation of an adaptive grid into a numerical model of droplet combustion that uses complex chemistry presents several challenges. The large number of dependent variables in the problem makes it difficult to develop appropriate criteria for concentrating grid points. The fluid mechanics and heat transfer form different regions of small scale in droplet combustion, and similar problems [23]. A dense grid is required near the droplet surface to adequately determine velocity and temperature gradients, and the droplet surface regresses due to evaporation of the fuel. Regions adjacent to and within the flame front must have sufficient detail to determine the location of the flame and to model the rapid chemical reactions. For large "droplets" (porous spheres), when an envelope flame is present at high velocities the flame is concentrated in a thin region that is close to the droplet surface along the upstream side of the droplet and that extends many diameters on the downstream side of the droplet (see for example [24-26]). The presence of different combustion regimes (envelope flame, transition flame, wake flame, and pure vaporization) and the transition between these regimes corresponds to large changes in the location of high temperature regions. The rapid changes in temperature will necessitate the use of an adaptive time-step to limit the grid point motion and capture the fundamental physics during "highly transient" periods (such as convective extinction) of the droplet lifetime.

The CEFD CRT will include an adaptive grid system and adaptive time-step in their numerical model of droplet combustion. This team will start with adaptation in the radial-direction only (one dimension) with an implementation similar to that of Dwyer [23] (which was based on the velocity gradient and the first and second derivatives of temperature with respect to the radial coordinate). A two-sided hyperbolic tangent stretching function [27] will be used to give a fixed, nonuniform grid distribution in the polar-direction, with grid points concentrated near the axis of symmetry to capture details in the wake of the droplet and at the forward stagnation-point where convective extinction occurs. This initial grid adaptation scheme requires minimal computational effort and is relatively easy to implement. The adaptive time-step will be implemented by using absolute limits on both the movement of grid points during a given time-step (i.e. grid point velocity) and the change of temperature or velocity during a given time-step. Extension of this relatively simple adaptive scheme to two-dimensional grid adaptation will be investigated. A completely general two-dimensional scheme (such as elliptic grid generation with control functions based on all of the dependent variables present in the current problem and their spatial derivatives) would be computationally prohibitive at best and may even be impossible at the present time.

C. Numerical Methods

The unsteady governing equations for conservation of mass, momentum, species, and energy will be transformed to general nonorthogonal coordinates [28] and discretized using the finite-volume [29] method. A pressure/velocity collocated scheme [30] will be used with the SIMPLEC [31] method to derive the pressure correction equation. The resulting discretization

equations will be solved using an alternating-direction implicit (ADI) scheme. Each time-step will require an iterative solution.

The grid system will regress with the droplet surface. A fixed physical location for the computational infinity is required to allow for expansion and contraction of the flame radius during the droplet lifetime. An adaptive grid using a one-dimensional transformation approach [22] based on temperature and velocity gradients will be employed in the radial direction. A two-sided hyperbolic tangent stretching function [27] will be used to give a fixed, nonuniform grid distribution in the polar-direction, with grid points concentrated near the axis of symmetry. The time-step will adapt based on absolute limits for grid point velocities and for the rate of change of temperature and velocity at the grid points. The large number of dependent variables introduced by the use of semi-detailed chemical kinetics results in enormous computational requirements that necessitate the use of massive parallel computing.

Experiments on droplet combustion at low ambient temperatures use an external spark to cause ignition after the droplet is deployed. In the numerical model, the droplet deployment will be modeled as a short time interval in which the droplet evaporates in the specified low temperature environment. Ignition will then be accomplished by inserting a high temperature region near the droplet to simulate the spark.

D. Outreach Education and Extension

Outreach education and extension is a priority of the CEFD CRT, with three areas of outreach education and extension incorporating the fuel droplet study. Through a collaborative effort with GFRC, CEFD researchers will demonstrate microgravity experiments to students in grades 9-12 and post secondary levels. These demonstrations will include the traveling tower kit from GFRC to demonstrate how the combustion process changes due to microgravity. The principles of physics and chemistry will be presented to show how the effect of gravity plays on earth.

Secondly, information and data gathered from the researchers' transient numerical simulations will be made available over the World Wide Web and on CD-ROMs. Video broadcasts of transient simulations will be posted on the Web in a streaming format so that instructors and students can see the research in action. For those individuals that do not have access to the Web or do not have the speed capabilities to view video on the Web, CD-ROMs will be developed, distributed through state extension agencies, and utilized in classroom settings throughout Nebraska.

During the past several years, the Native American Outreach component of NSGC has been actively involved with the Winnebago, Santee Sioux, and Omaha Nation school districts as well as both NICC and Little Priest Tribal College. The Family Aeronautical Science Project is currently integrating NASA Nebraska EPSCOR research into its activities. Dr. Gogos and his team will support this initiative by making microgravity demonstrations to Family Science participants (administrators, teachers, students, and their parents) and designing related learning modules. Future activities may also include researchers and Native American School faculty at both the elementary, secondary, and higher education levels working on portions of the research.

E. Technology Transfer

NASA Nebraska EPSCoR is committed to the identification and development of technology transfer opportunities. The technology transfer phase of the research project will transform the designs, ideas, research, and innovations of Nebraska researchers to the development phase where the project will be nurtured by identified technology transfer experts, eventually leading to utilization applications. The team has identified many organizations and

individuals to contact for assistance in the technology transfer phase. At a minimum, the team has identified an individual at each NASA Center where the research collaborators are located as well as national, regional, and state technology transfer organizations to contact for expertise.

In order to ensure the proper transfer of technology, Dr. Gogos will work with Dr. Vedha Nayagam, Principal Researcher, at NASA's Glenn Flight Research Center (GFRC). Dr. Gogos will also seek the expertise of Mr. Larry Viterna, Chief of the Commercialization Technology Office at GFRC.

II. Metrics for Tracking and Evaluating Program Progress

The activities of the CEFD CRT will be managed by Dr. George Gogos, the principal investigator. Dr. Gogos has a successful history of leading and managing grant funded research endeavors (including projects supported by NASA EPSCoR) and will apply this experience to ensure that the objectives of the proposed research are met on a timely basis. Dr. Gogos will (a) oversee the procurement and installation of equipment; (b) coordinate the research activities of his colleagues and graduate students; and (c) oversee program evaluation and reporting, collaboration with NASA researchers, technology transfer, and program evaluation.

In the same fashion as Years 1-3, Dr. Gogos will continue to hold monthly meetings with key project personnel to ensure optimal program coordination and timely progress toward achievement of the proposed research outcomes. Dr. Gogos will also continue to provide written semi-annual reports to Dr. Bowen, NASA Nebraska EPSCoR Director.

Dr. Gogos will meet at least semi-annually with Nebraska AERIAL administrators to brief them on the activities of this research team. He will also attend and present progress reports at all semi-annual NASA Nebraska EPSCoR TAC meetings. This state-wide advisory committee, already in operation, represents a broad variety of science, technology, industry, and economic development interests throughout the state. As appropriate, Dr. Gogos will confer independently with individual TAC members to ensure alignment with state technology and economic goals.

Like the principal investigators from the other CRTs, Dr. Gogos will provide AERIAL administrators, the NASA Nebraska EPSCoR TAC, and NASA administrators with evidence of scientific accomplishment and communication of those accomplishments through (a) scientific publications, (b) presentations at academic conferences and symposia, (c) increased collaboration with NASA and other researchers in the state, (d) contributions to industry, (e) patents, (f) proposal submissions to other funding sources, and (g) improvements in infrastructure. These evaluation reports will be available for review on the AERIAL website.

The evaluations and ensuing feedback from AERIAL administrators, TAC members, NASA administrators and researchers, and other stakeholders will form the basis for continuous improvement activities. If necessary, and with the advance approval of Dr. Bowen, Dr. Gogos, as principal investigator, will implement modifications to the design of the project to ensure timely and ultimate achievement of the research goals and objectives. Consistent with Nebraska AERIAL policy, Dr. Gogos will compile progress reports on a quarterly basis. These reports will include briefings on progress to date as well as indicators of program impact (i.e., new funding sources sought/received, descriptions of expanded or new NASA collaborations, progress toward transfer of technology, number and type of publications in development/accepted, and presentations at academic conferences).

Finally, Dr. Vedha Nayagam, CEFD Technical Monitor and Principal Investigator of the National Center for Microgravity Research at NASA GFRC, has agreed to continue to provide microgravity experimental data for validation of our numerical codes into Years 4 and 5:

III. Milestones & Timetables for Achieving Specific Objectives During Award Period

Table 1 (below) presents the CEFD time schedule to accomplish the proposed research. At the inception of the proposed work this team will have a quasi-steady (Q-S) and a transient (T) numerical model with single-step kinetics and the associated code parallelized to run at both the UNL computing facility and the National Center for Supercomputer Applications at UIUC. During Year 4, the CEFD CRT's major goal will be the introduction of adaptive gridding both in the quasi-steady and the transient code. During Year 5, this team will introduce at least semi-detailed (and possibly detailed) chemical kinetics to the quasi-steady and transient code.

Results from the transient codes will be captured on video. This video (together with the additional material that is available at GFRS and in collaboration with NASA) will be used for outreach activities.

Year	Quasi-Steady (Q-S) or Transient (T)	Chemical Kinetics	Parallel Code	Adaptive Grid
4 th	Q-S	single-step	Parallel	Adaptive
	T	single-step	Parallel	Adaptive
5 th	Q-S	semi-detailed or detailed	Parallel	Adaptive
	T	semi-detailed or detailed	Parallel	Adaptive

Table 1: Time schedule of proposed work.

One of the major indicators of success for this and all AERIAL research activities will be the identification, application for, and attainment of external funding (from both private and non-NASA federal sources) to further the research aims of this and the other AERIAL CRTs. The likelihood of success in this endeavor is high given (a) the appropriateness of this CRT's outcomes to the aerospace industry, (b) its relevance to the state's economic development, and (c) the scientific value of its potential research outcomes. Progress toward success in this regard will be assessed through the aforementioned semi-annual CRT progress reports and shared with AERIAL administrators, TAC members, and NASA personnel.

IV. Potential to Achieve Self-sufficiency Beyond the Award Period of This Grant

CEFD Principal Investigator Gogos' success in securing non-NASA funding is expected to continue well beyond Years 4 and 5. The CEFD proposed research for Years 4 and 5 has been shown to have great importance to a number of agencies. Continuation of funding through NASA EPSCoR would prevent disruption to the CEFD research personnel that are in place. In addition to the existing personnel, two new doctoral students will join the project during Fall 2004. During Years 4 and 5, Dr. Gogos will submit proposals for funding in the droplet combustion area to the NASA Microgravity Combustion Science Program (Dr. Merrill King, Program Manager), to the Army Research Office (Dr. David Mann, Program Manager) and to the Air-Force Office of Scientific Research (Dr. Julian Tishkoff, Program Manager).

V. Potential for Future Growth in Importance in Aerospace Fields

Advances in convective extinction of fuel droplets are of great interest for practical combustion devices and address one of the long-term goals of the HEDS microgravity combustion program. The development of a validated model for the convective extinction of fuel

droplets will enhance a well-defined flight definition experiment currently sponsored by the NASA Microgravity Combustion Science Program.

CEFD's proposed and previous work (funded by NASA EPSCoR) constitutes systematic research steps in a long-term effort to study droplet combustion. Completion of the proposed work will contribute fundamental understanding on how chemical kinetics and fluid dynamics couple. This could be very important for future combustion science research.

This proposed research will have a direct impact on the economic development of Nebraska. It will help the CEFD CRT to attract external funding to assist in migrating from EPSCoR funding to other sources before completion of the proposed work. The Nebraska research infrastructure will be enhanced and opportunities will be offered to citizens of Nebraska to be involved with cutting edge research.

The growth of this CRT in terms of relevance and importance will be measured through (a) the number and variety of accepted articles in juried academic journals; (b) presentations by CRT personnel at academic, NASA-sponsored, and other technical conferences and symposia; (c) inclusion of the research outcomes in technical reports and studies; (d) increased collaborative activity among CRT investigators, NASA researchers, and other academic researchers; and (e) new funding sources and levels. Dr. Gogos and his team will continue to work in concert with Technical Monitor Dr. Vedha Nayagam and leading members of the combustion community

Attachment 1. References Cited in CEFD Report of Progress

- [1] R. Seiser, L. Truett, D. Trees and K. Seshadri, *Proceedings of the Combustion Institute*, 27:649-657 (1998).
- [2] C. K. Westbrook and F. L. Dryer, *Combustion Science and Technology*, 27:31-43 (1981).
- [3] D. N. Pope and G. Gogos, "A New Multicomponent Diffusion Formulation for the Finite-Volume Method," in preparation for *Numerical Heat Transfer, A*.
- [4] D. N. Pope and G. Gogos, "Numerical Simulation of n-Heptane Droplet Extinction Due to Forced Convection", in preparation for *Combustion and Flame*.
- [5] L. Krishnamurthy, F. A. Williams and K. Seshadri, *Combustion and Flame*, 26:363-377 (1976).
- [6] D. N. Pope, D. Howard, K. Lu and G. Gogos, "Combustion of Moving Droplets and of Droplets Suspended within a Convective Environment: Transient Numerical Results", in preparation for journal publication.
- [7] R. C. Reid, J. M. Prausnitz and B. E. Poling, *The Properties of Gases and Liquids*, McGraw Hill, 1987.
- [8] B. J. McBride, S. Gordon and M. A. Reno, *NASA Technical Memorandum 4315*, 1993.
- [9] A. S. Teja and P. Rice, *Ind. Eng. Chem. Fundam.*, 20:77-81 (1981).
- [10] A. S. Teja, *J. Chem. Eng. Data*, 28:83-85 (1983).
- [11] N. B. Vargaftik, Y. K. Vinogradov and V. S. Yargin, *Handbook of Physical Properties of Liquids and Gases: Pure Substances and Mixtures*, 3rd Ed., Begell House, Inc., 1996.
- [12] Y. E. Lee and F. Y. Li, *J. Chem. Eng. Data*, 36:240-243 (1991).
- [13] K. Kurihara, M. Nakamichi and K. Kojima, *J. Chem. Eng. Data*, 38:446-449 (1993).

Attachment 2. References Cited in the CEFD Request for Continuation

- [1] M. C. Hicks, N. Kaib, J. Easton, V. Nayagam and F. A. Williams, *Third Joint Meeting of the U.S. Sections of the Combustion Institute*, Chicago, IL, March 16-19, 2003.
- [2] S. Okajima, and S. Kumagai, *Proceedings of the Combustion Institute*, 15:401-407 (1975).
- [3] B.D. Shaw, F.L. Dryer, F.A. Williams, and J.B. Haggard, *Acta Astronaut.*, 17:1195-120 (1988).
- [4] G.S. Jackson, C.T. Avedisian and J.C. Yang, *Proc. R. Soc. Lond.*, A435:359-369 (1991).
- [5] C.T. Avedisian, *Physical and Chemical Aspects in Combustion*, pp. 135-160, Gordon and Breach, 1997.
- [6] C.T. Avedisian, personal communication.
- [7] A.L. Randolph and C.K. Law, *Combustion and Flame*, 64:267-284 (1986).
- [8] D. N. Pope and G. Gogos, "Numerical Simulation of n-Heptane Droplet Extinction Due to Forced Convection", in preparation for *Combustion and Flame*.
- [9] A.J. Marchese, F.L. Dryer and V. Nayagam, *Combustion and Flame*, 116:432-459 (1999).
- [10] H. Bedir and J. S. Tien, *Proceedings of the Combustion Institute*, 27:2821-2828 (1998).
- [11] J. L. Rhatigan, H. Bedir and J. S. Tien, *Combustion and Flame*, 112:231-241 (1998).
- [12] D. N. Pope and G. Gogos, "A New Multicomponent Diffusion Formulation for the Finite-Volume Method," in preparation for *Numerical Heat Transfer*, A.
- [13] D. N. Pope, D. Howard, K. Lu and G. Gogos, "Combustion of Moving Droplets and of Droplets Suspended within a Convective Environment: Transient Numerical Results", in preparation for journal publication.
- [14] C. K. Westbrook and F. L. Dryer, *Comb. Sci. and Tech.*, 27:31-43 (1981).
- [15] C. K. Westbrook, J. Warnatz, and W. J. Pitz, *Proceedings of the Combustion Institute*, 22:893-901 (1988).
- [16] R. P. Lindstedt and L. Q. Maurice, *Comb. Sci. and Tech.*, 107:317-353 (1995).
- [17] H. J. Curran, P. Gaffuri, W. J. Pitz, and C. K. Westbrook, *Combust. Flame*, 114:149-177 (1998).
- [18] G. S. Jackson and C. T. Avedisian, *Combust. Sci. and Tech.*, 115:125-149 (1996).
- [19] J. Warnatz, *Proceedings of the Combustion Institute*, 20:845-856 (1984).
- [20] A. Chakir, M. Bellimam, J. C. Boettner, and M. Cathonnet, *Int'l J. of Chemical Kinetics*, 24:385-410 (1992).
- [21] T. J. Held, A. J. Marchese, and F. L. Dryer, *Comb. Sci. and Tech.*, 123:107-146 (1997).
- [22] J. F. Thompson, *Applied Numerical Mathematics*, 1:3-27 (1985).
- [23] H. A. Dwyer, *AIAA Journal*, 22:1705-1712 (1984).
- [24] D. B. Spalding, *Fuel*, 32:169-185 (1953).
- [25] S. R. Gollahalli and T. A. Brzustowski, *Proceedings of the Combustion Institute*, 14:1333-1344 (1973).
- [26] S. R. Gollahalli and T. A. Brzustowski, *Proceedings of the Combustion Institute*, 14:409-417 (1975).
- [27] M. Vinokur, *Journal of Computational Physics*, 50:215-234 (1983).
- [28] M. Vinokur, *Journal of Computational Physics*, 14:105-125 (1974).
- [29] S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere, 1980.
- [30] M. Peric, R. Kessler, and G. Scheuerer, *Comp. Fluids*, 16:389-403 (1988).
- [31] J. P. VanDoormaal and G. D. Raithby, *Numerical Heat Transfer*, 7:147-163 (1984).

NASA NEBRASKA EPSCoR

SMALL AIRCRAFT TRANSPORTATION SYSTEM (SATS)

Dr. Scott Tarry, PI
University of Nebraska at Omaha Aviation Institute
6001 Dodge Street
Allwine Hall 422
Omaha, NE 68182

(402) 554-3424 phone
(402) 554-3781 fax
starry@mail.unomaha.edu

Cooperative Agreement #: NCC5-572

Submitted: April 30, 2004

Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Report of Progress for the

**Small Aircraft Transportation System (SATS)
Collaborative Research Team (CRT)**

I. Original Proposal Abstract

The proposed work of the Small Aircraft Transportation System (SATS) Collaborative Research Team builds on accomplishments supported by NASA Space Grant and NASA Nebraska EPSCoR Preparation Grant funding during the past two years. The work of the team encompasses several critical, interrelated technical areas: systems engineering, economic modeling, assessment of network organization potential, implementation feasibility analysis, education and outreach, and technology transfer.

SATS is an inter-modal, rapid transit air travel system. The research of the past two years was initiated to support the national implementation of SATS via a primary focus on Nebraska and a secondary focus on the Great Plains region. Past studies were designed to:

- Define SATS and some of its key requirements,
- Frame the more important public finance questions and possible solutions,
- Document the current status of the general aviation sector in Nebraska,
- Identify major policy issues facing the small and rural local governments that will be called on to play a key role in implementing SATS, and
- Provide a body of reference material and faculty expertise for successful implementation.

The implementation of a small aircraft transportation system (SATS) holds the potential for significantly enhancing the provision of air transport services to communities that are not well served by the nation's traditional air transport system. Nebraska includes numerous small communities and rural and isolated areas. Much of the state has not reaped the full benefits of air transport since there is not sufficient demand for attracting airline service. Attempts by the federal government to address this issue, primarily through subsidy programs like Essential Air Service, have not improved access to cost-effective air transport services. SATS offers the potential to bring safe, cost-effective, accessible air transport services to hundreds of thousands of Nebraskans and to thousands of the state's small businesses who are not able to make efficient use of the hub and spoke system that dominates the air transport industry.

The proposed work allows the Nebraska SATS team to continue developing and expanding our general aviation alliances. We will continue to work with NASA research centers, Nebraska state government agencies, Nebraska local governments, and other general aviation stakeholders to extend our understanding and readiness to implement SATS as a part of a national system. The proposed work will allow the team to continue to develop and expand our research and product development linkages with these same entities. The proposed research activities and national, state, and corporate research linkages will result in research products providing both immediate and long-term economic benefits to Nebraska and the Great Plains region.

II. Team Accomplishments

The SATS CRT has made excellent progress in meeting the goals set out in the original proposal. The Nebraska CRT has played a key role in helping NASA define the SATS concept.

In fact, the work done by the CRT helped NASA reshape the focus of the program away from futuristic personal air vehicles and towards the advance light jet air taxi concept, which defines SATS today. The CRT has contributed to the development and refinement of decision system support models. Massoum Moussavi and Scott Tarry have actively participated in the on-going work of the SATS Transportation Systems Analysis and Assessment Working Group, which is led by Stuart Cooke, Jr. of NASA Langley Research Center. Their involvement means that the work conducted by the CRT is fully integrated into the broader cooperative effort that includes researchers from NASA and a variety industry and academic partners. The CRT's work to establish a base-line assessment of air transport in Nebraska and the Great Plains has helped NASA and other researchers more fully understand the prospects for implementing SATS.

The CRT has also made significant progress in meeting the broader goals of the EPSCoR program. The CRT has produced a steady stream of research outcomes. These outcomes have been validated externally through the peer review processes of various academic journals and conferences. Many of the outcomes have also been validated through NASA's internal review processes. The CRT has also begun to achieve self-sufficiency. Members of the CRT have successfully competed for non-EPSCoR funding. EPSCoR funding has given the CRT the opportunity to build a substantial foundation of knowledge and expertise that will allow the members of the CRT to effectively compete for a variety of funding opportunities at the state and national level.

The SATS CRT has experienced high levels of research success as it moves toward completion of its third year of AERIAL funding. Such success is evident in the comprehensiveness of the various outcomes that have resulted from the SATS team's work. This progress is documented in Attachment 1.

III. SATS Articles Submitted to and/or Published in Refereed Journals

1. Bartle, J. (in press). Transportation infrastructure. *Handbook of Public Sector Economics*.
2. Bartle, J., & Korosec, R.L. (in print). A review of state procurement and contracting. *Journal of Public Procurement*, 3.
3. Bowen, B. & Scarpellini-Metz, N. (under review). A research case study: Exploring the influence of AGATE. *Public Works Management and Policy*.
4. Holmes, B., Tarry, S., & Durham, M. (in press). The Small Aircraft Transportation System (SATS) concept and technologies. *Journal of Aircraft*.
5. Moussavi, M., & Vargas, J., (under review). Planning and design of Small Aircraft Transportation System (SATS) in Nebraska. *ASCE Journal of Transportation Engineering*.
6. Bowen, B. & Scarpellini-Metz, N. (Winter 2004). AGATE outcomes analysis: Laying the foundation for SATS. *Journal of Aviation/Aerospace Education and Research*.
7. Tarry, S., O'Neil, P., El-Kassaby, B., Pate, J., & Thalman, E. (2004). NASA small aircraft transportation system: Analyses of stakeholder perceptions. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE, 21.
8. Moussavi, M., & Vargas, J. (2004). Application of SATs modal choice analysis computer program. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE, 21.
9. Tarry, S., Vlasek, K., & El-Kasaby, B. (2003). Aviation insurance and the implementation of the Small Aircraft Transportation System (SATS) *Journal of Air Transport Management*, 9, 299-308.

10. Nickerson, J., Moussavi, M., Smith, R., Tarry, S., & Bowen, B. (2002). Innovatively saving the future of transportation: The Small Aircraft Transportation System (SATS). *Journal of Public Transportation*, 5(3), 67-82.
11. Bonkiewicz, T., & Bowen, B. (2002, October). Analytic assessment of general aviation security issues in the Post 9-11 environment: Implications for the Small Aircraft Transportation System (SATS). *Collegiate Aviation Review*, 20(1), 17-28.
12. Tarry, S., & Bowen, B. (2001). Optimizing airspace system capacity through a Small Aircraft Transportation System. *Journal of Air Transportation World Wide*, 6(1), 65-76.

IV. List of Patents Pursued by the SATS CRT

No patents have been pursued by the SATS CRT.

V. Participation in Professional Events

1. Moussavi, M. (2004, April 16). Application of SATS modal choice analysis computer program. [Abstract]. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE, 21-22.
2. Moussavi, M., & Vargas, J. (2004, January). Small Aircraft Transportation System modal choice analysis. *Proceedings of the 83rd Annual Meeting of the Transportation Research Board*: Washington, DC, Compendium of papers (CD-ROM), 1-17.
3. Tarry, S. (2003, December). *SATS in Nebraska*. Research presented for the Aerospace Technology Working Group, Centennial of Flight Symposium: Hampton, VA.
4. Moussavi, M. (2003, December 11). *Small Aircraft Transportation System (SATS): Nebraska implementation*. Paper presented to the National Aeronautics and Space Administration, Hampton, VA.
5. Moussavi, M. (2003, December 11). *Small Aircraft Transportation System (SATS)*. Research presented at the Transportation Systems Analysis & Assessment and NASA SATS Technical Coordinating Committee Meeting, NASA Langley Research Center: Hampton, VA.
6. Holmes, B., Tarry, S., & Durham, M. (2003, July). *The Small Aircraft Transportation System (SATS) concept*. Paper accepted for presentation at the AIAA-ICAS International Air & Space Symposium and Exposition, Dayton, Ohio.
7. Tarry, S. (2003, June). *The future of air transport: The Small Aircraft Transportation System*. Research presented at the Airports Symposium, Airports Council International – North America: Minneapolis, MN.
8. Tarry, S.E., & Moussavi, M. (2003, June). *Implementing SATS in the upper great plains*. Research Report submitted to North Carolina/Upper Great Plains SATS Lab and Transportation Systems Analysis and Assessment Working Group, NASA Langley Research Center: Hampton, VA.
9. Bartle, J. (2003, April 25). The sustainable development of transportation infrastructure: An institutional perspective [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27-28.
10. Bonkiewicz, T., & Bowen, B. (2003, April 25). General aviation security issues impacting the Small Aircraft Transportation System in the post 9-11 environment [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 28.

11. Metz, N., & Bowen, B. (2003, April 25). AGATE/SATS: A case study in federal program management. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 23.
12. Moussavi, M. (2003, April 25). Decision support model for implementing Small Aircraft Transportation System (SATS) in Nebraska [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27.
13. Tarry, S., Vlasek, K., & El-Kasaby B. (2003, April 25). A comparison of the Small Aircraft Transportation System to existing transportation system options in Nebraska [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27.
14. Tarry, S., Vlasek, K., & El-Kasaby B. (2003, April 25). Aviation insurance and the implementation of the small aircraft transportation system [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 34.
15. Tarry, S. (2003, April). *Alternatives to Essential Air Service (EAS) and public service obligation routes: Air transport in remote regions*. Paper presented at the 3rd Annual Forum on Air Transport in Remote Regions: Cork, Ireland.
16. Bartle, J. (2003, March). *A two-sector economic model of technological progress in air transportation: Implications for public investment*. Poster session presented at the annual meeting of the NASA Experimental Program to Stimulate Competitive Research Program: Washington, DC.
17. Tarry, S. (2003, March). *Air transportation in rural communities*. Paper presented at Annual Meeting of the American Society for Public Administration: Washington, DC.
18. Tarry, S. (2003, March). *Policy options for rural America: Comparing the Small Aircraft Transportation System (SATS) and the Essential Air Service (EAS)*. Paper presented at the Annual Meeting of the American Society for Public Administration, Washington, DC.
19. Tarry, S., Bartle, J., & Moussavi, M. (2003, March). *Small Aircraft Transportation System (SATS): Research collaborations with the NASA Langley Research Center*. Poster session presented at the annual meeting of the NASA Experimental Program to Stimulate Competitive Research Program, Washington, DC.
20. Tarry, S., Bartle, J., & Moussavi, M. (2003, March). *Implementing SATS in Nebraska*. Paper presented at the Annual Meeting of the NASA Experimental Program to Stimulate Competitive Research Program: Washington, DC.
21. Tarry, S., & Bonkiewicz, T. (2003, March). *Assessing the role of privately owned public use airports*. Paper presented at the Annual Forum of the Transportation Research Forum: Washington, DC.
22. Moussavi, M., & Vargas, J., (2003, January 12-16). *Small Aircraft Transportation System (SATS): Nebraska implementation*. Research presented at the 82nd Annual Meeting of Transportation Research Board: Washington, DC, 1-18.
23. Tarry, S., & Moussavi, M. (2002, October, 29). *Implementing the Small Aircraft Transportation System (SATS) in Nebraska and the Great Plains states*. Paper presented to the Transportation Systems Analysis and Assessment Working Group, NASA Langley Research Center: Hampton, VA.
24. Fink, M., Bowen, B., Tarry, S., et al. (2002, September). *The upper Great Plains Small Aircraft Transportation System (SATS) plan*. Paper presented at the Western Region NASA Space Grant Conference: Big Sky, MT.

25. Moussavi, M. (2002, September 25-27). *NASA's Small Aircraft Transportation System (SATS)*. Paper presented at the Missouri Valley Section of the Institute of Transportation Engineers (MOVITE) Annual Meeting: Omaha, NE.
26. Bowen, B., & Metz, N. (2002, July). Policy research, a case in agency transition: The NASA AGATE/SATS program. *Proceedings of the Air Transport Research Society International Conference*: Seattle, WA.
27. Tarry, S., Vlasek, K., & El-Kasaby, B. (2002, July). Aviation insurance and the development of advanced small aircraft. *Proceedings of the Air Transport Research Society International Conference*: Seattle, WA.
28. Tarry, S., Moussavi, M., El-Kasaby, B., et al., (2002, June). *Implementing the Small Aircraft Transportation System (SATS) in Nebraska*. Research findings presented to North Carolina/Upper Great Plains SATS Lab.
29. Bowen, B. (2002, April). *Collegiate aviation education: Opportunities through research, the SATS 101 example*. Research presented to the National Congress on Aerospace Education, Washington, D.C.
30. Metz, N., & Bowen, B. (2002, April 26). Policy research results from a retrospective assessment of the NASA AGATE program: Implications for NASA SATS [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 22.
31. Moussavi, M. (2002, April 26). An inventory study of the potential Small Aircraft Transportation System landing facilities in Nebraska [Abstract]. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE, 22-23.
32. Tarry, S., El-Kasaby, B., & Vlasek, K. (2002, April). *New technologies and policy change: Advanced small aircraft and rural transport*. Paper presented at the Annual Meeting of the Midwest Political Science Association: Chicago, IL.
33. Tarry, S., & El-Kasaby, B. (2002, April 26). Technology-based solutions for rural transportation: The Small Aircraft Transportation System (SATS) [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 22.
34. Tarry, S., & Vlasek, K. (2002, April 26). An examination of insurance issues surrounding the Small Aircraft Transportation System (SATS) [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 23.
35. Bowen, B. (2002, March). *SATS research update, Aerospace Technology Working Group (ASTWG) session*. Research presented at the National Council of NASA Space Grant Directors Meeting, Washington, D.C.
36. Bowen, B. (2002, March). *SATS research update*. Research presented at the National Council of NASA Space Grant Directors, Aerospace Technology Working Group: White Sands Research Facility, NM.
37. Moussavi, M. (2001). *SATS system dynamics modeling*. Research presented at the SATS Systems Engineering Workshop. NASA Langley Research Center: Hampton, VA.
38. Moussavi, M. (2001). *A systems engineering approach for managing Small Aircraft Transportation System planning, design, and operations*. Paper presented to the National Aeronautics and Space Administration: Hampton, VA.
39. Bowen, B., & Metz, N. (2001, October). The policy research construct: Applications to aviation and space research. [Abstract] *Research Roundtable, Fall Conference of the University Aviation Association*: Nashville, TN.

40. Tarry, S. (2001, October). *Industry Panel Discussion on the Small Aircraft Transportation System Chairperson*. Annual Forum of the Transportation Research Forum: Williamsburg, VA.
41. Bowen, B., & Tarry, S. (2001, October) Identification of public policy perspectives in the deployment of the Small Aircraft Transportation System (SATS). *43rd Annual Proceedings of the Transportation Research Forum*, 1-8.
42. Bowen, B. & Tarry, S. (2001, October). *Identification of public policy research applications in the deployment of a new air transportation system component*. Paper presented at the Annual Meeting of the Transportation Research Forum: Williamsburg, VA.
43. Bowen, B. (2001, August). *Nebraska Small Aircraft Transportation System (SATS) work-plan update recommendations*. Paper presented at the SATS Leadership Team Meeting at NASA Langley Research Center: Hampton, VA.
44. Tarry, S., & Bowen, B. (2001, August). *The Nebraska work plan for SATS Research*. Paper presented at the meeting of the Research Triangle Institute SATS Forum: Raleigh, NC.
45. Tarry, S. (2001, May). *Facilitated workshop on the Small Aircraft Transportation System*. NASA Langley Research Center Research Symposium: Hampton, VA.
46. Tarry, S. (2001, May). *Prospects for a Small aircraft Transportation System*. Paper presented at FAA Central Region 2001 Airports Conference: Kansas City, MO.
47. Moussavi, M. (2001, April 20). A framework for developing a decision support simulation model for Small Aircraft Transportation System [Abstract]. *Proceedings of the 121st Annual Nebraska Academy of Sciences*: Lincoln, NE.
48. Moussavi, M. (2001, April 20). A framework for developing a decision support simulation model for Small Aircraft Transportation System [Abstract]. *Proceedings of the 121st Annual Nebraska Academy of Sciences*: Lincoln, NE.
49. Moussavi, M. (2001, April 19). *A systems engineering approach for managing Small Aircraft Transportation System (SATS)*. Paper presented at the Annual Meeting of the Nebraska Section of the American Society of Civil Engineers: Omaha, NE.
50. Moussavi, M. (2001, February 20). *A framework for developing a decision support simulation model for Small Aircraft Transportation System*. Paper presented to the National Aeronautics and Space Administration, NASA Langley Research Center: Hampton, VA.
51. Tarry, S. (2001, January). *Small Aircraft Transportation System Overview*. Paper presented at the Nebraska Aviation Symposium: Kearney, NE.

VI. Follow-on Grant Proposals Submitted and Funded

During the course of the project, SATS CRT leaders and investigators pursued funding beyond that which was provided by the AERIAL grant. In total, the **SATS CRT secured an additional \$308,000 in non-NASA research funding**. The grants pursued by the SATS team are highly collaborative, involving various researchers and departments at UNO. Specifically, the SATS team applied for three separate grants offered by the Research Triangle Institute (RTI), which focused on planning, case studies, and system development.

- The first grant, coordinated by Dr. Scott Tarry, was awarded by RTI for research titled "Small Aircraft Transportation Planning." This award provided an additional

\$127,000 to support evaluation of Nebraska's current air transport system and infrastructure and the state's ability to accommodate SATS.

- The second RTI grant, in the amount of \$37,000, was awarded for completion of a specific SATS CRT research project titled "SATS Business Case System Studies." This project complements AERIAL SATS research by evaluating various SATS business models in the context of Nebraska's transportation system.
- Finally, RTI awarded the SATS CRT with an additional \$144,000 to complete a project titled "System Support Modeling and Business Case Development for SATS in Nebraska." This project began in June 2003 and focuses on the development of a decision support model and SATS business case for Nebraska, including a statewide airport survey. This contract allowed the Nebraska SATS research team to expand its efforts and undertake additional work requested by its partners at NASA. The work completed through NCAM concluded in December 2003.

VII. Confirmation of Technical Monitor Contact and Involvement

Throughout the period of AERIAL funding, Principal Investigator Tarry has maintained at least quarterly research and collaborative contact with the SATS CRT Technical Monitor, Dr. Bruce Holmes, Associate Director for Airspace and Vehicle Systems Integration, NASA LaRC. Tarry and Holmes communicate via phone and e-mail on a nearly monthly basis. Tarry and Holmes co-authored a paper with Mike Durham, also of NASA LaRC, which was presented at the AIAA national meeting in 2003. This paper is being published in *Journal of Aircraft*. Tarry also maintains close contact with the primary SATS researchers at LaRC. Tarry and Moussavi maintain almost weekly contact with Stuart Cooke, TSAA lead at LaRC and primary liaison for the SATS CRT, via teleconferences and face-to-face meetings. The efforts of the CRT are fully integrated into the research agenda of the TSAA and are responsive to the more general guidance received from Dr. Holmes.

Dr. Holmes has provided confirmation of his support of SATS CRT research progress during the first three years of funding. Specifically, Dr. Holmes provided notification of his review and approval of the SATS Year 2 Report, Year 3 Proposal, the above SATS Research Area Award Report of Progress, and the following SATS Research Area Award Request for Continuation.

VIII. SATS Personnel Information

SATS CRT member	Male	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty	4		3		1	
Post-Doctoral						
Staff	1		1			
Graduate Student	4		2		1	1
Undergraduate Student						

SATS CRT member	Female	American Indian or Alaskan Native	White, Not of Hispanic Origin	Black, Not of Hispanic Origin	Asian or Pacific Islander	Hispanic
Faculty						
Post-Doctoral						
Staff	5		5			
Graduate Student	1		1			
Undergraduate Student						

IX. Progress Toward Achieving Self-sufficiency Beyond Award Period

As noted above, the SATS CRT has been successful in its pursuit of non-EPSCoR funding opportunities. Members of the CRT have been awarded over \$300,000 in grants and contracts from the Research Triangle Institute and the National Consortium for Aviation Mobility to fund research and activities beyond what has been funded by EPSCoR. These grants reflect the value of the experience gained through the CRT's EPSCoR funded research and show that the CRT is making real strides to move towards self-sufficiency. The CRT continues to conduct research specific to the NASA-led SATS initiative, but it is also taking a broader view of aviation and transportation systems analysis. Members of the CRT are gaining valuable experience and knowledge through their EPSCoR funded work, which will allow them to move beyond SATS and compete successfully for other transportation systems analysis research grants.

X. Research Results

As can be seen from the listed publications and other activities related to the CRT's research program, the last three years have been very productive. The work conducted by the CRT, while clearly focused on SATS, is not confined to a single discipline or topical area. Research undertaken by CRT members includes policy analysis, business case development, systems engineering and decision support analysis, and financial analysis. In each case, the CRT is making progress towards its larger objective of conducting research that is both credible and useful to decision makers within and outside NASA. In addition to their own research projects, CRT members Dr. Scott Tarry and Dr. Massoum Moussavi have also played ongoing roles in the Transportation Systems Analysis and Assessment (TSAA) Working Group that is guiding systems research for NASA Langley SATS researchers and the National Consortium for Aviation Mobility (NCAM), which is the governing body for the public-private partnership established by Congress to lead the SATS initiative. The following narrative reports on the various projects that have been undertaken during the last three years as part of the CRT's broader research program.

Scott Tarry continues his role as the CRT's principal investigator. His work on SATS spans a number of substantive areas. Tarry's primary focus has been an assessment of SATS as an alternative to the Essential Air Service (EAS) program. EAS is the federal program that provides subsidized airline service to small communities around the nation. Despite its obvious flaws, the program persists because no viable alternative currently exists for plugging small and rural communities directly into the nation's air transport system. SATS offers the potential to provide these communities with a better solution to their air transport needs. Tarry's work combines an analysis of the EAS program as well as an assessment of the features of SATS that make it relevant for small community air service. The results from this work have been presented on panels at the 2003 Annual Forum of the Transportation Research Forum and the

2003 Annual Meeting of the American Society for Public Administration. These conferences provided opportunities to engage scholars and policymakers unfamiliar with the SATS concept. In particular, Tarry's participation in the Air Transport in Remote Regions Forum, which was held in Cork, Ireland, gave him the opportunity to present his SATS research to a European audience. As a result of his work on SATS, Tarry has been invited to serve on the advisory board for a new Center on Air Transport in Remote Regions, which has been established at Cranfield University in the United Kingdom. Tarry's interaction with scholars and policymakers outside the SATS and general aviation communities has given him important perspectives that he has shared with NASA and other SATS researchers through his active participation in the TSAA Working Group. Patrick D. O'Neil assisted Dr. Tarry on this and other projects. O'Neil is pursuing his Ph.D. in Public Administration and focusing his research on aviation and transportation policy. O'Neil has served as a liaison between the CRT and the Transportation Security Administration (TSA) and is assisting the CRT is exploring the impact of new or future security requirements on the implementation of the SATS concept, especially at small community airport facilities.

Tarry has also been involved in the drafting of a paper that conceptualizes the broader SATS vision. Written with Bruce Holmes, Associate Director of Airspace and Vehicle Systems Integration at NASA Langley Research Center, the paper was presented at the AIAA-ICAS International Air & Space Symposium and Exposition in Dayton, Ohio in June 2003. The paper is now in the process of being published in the *Journal of Aircraft*. This work reflects Tarry's efforts to facilitate the CRT's ongoing involvement in the conceptualization of this important innovation in air transport. The CRT through its various research projects has helped provide a regional perspective that is critical for the successful implementation of a system of transportation.

Bassel El-Kasaby, who serves as Tarry's doctoral research assistant, presented a paper co-authored by Tarry and Karisa Vlasek at the annual meeting of the Air Transport Research Society in Seattle. This paper, which focused on insurance issues related to SATS implementation, was selected from the slate of conference papers for inclusion in a special issue of the *Journal of Air Transport Management*. El-Kasaby and Tarry have also been invited to submit a paper to a special issue of the *International Journal of Public Administration*. While not focused exclusively on SATS, the paper provides an opportunity to provide additional exposure for the SATS concept to general transportation and public policy audiences. The CRT's work on aviation insurance also resulted in an industry workshop held during the Annual Conference of the National Business Aviation Association in Orlando, Florida in October 2003. Workshop participants included representatives from NASA, FAA, Boeing, Eclipse, Cessna, and a number of aviation insurance underwriters and brokers.

Massoum Moussavi leads the CRT's contribution to LaRC's on-going effort to develop a computer-based decision support system/model for SATS implementation. The primary focus of Moussavi's current work is the implementation of this model for managing SATS planning, design, and operation within the State of Nebraska. A direct outcome from these efforts was a Master's thesis by Moussavi's student, Jaime Vargas, who completed his MS in Civil Engineering on May 2002. Jaime continues to work on his Ph.D. dissertation with Moussavi on SATS project. The Nebraska decision support system/model includes demand forecasting, airfield design, terminal area and ground transportation requirements for SATS. The preliminary results of the application of this model have identified the requirements for SATS implementation under different scenarios of planning, design, and operations within the state of

Nebraska. The model development, testing, and calibration will continue by incorporating other sub-models into the existing model. These sub-models will include vehicle technology, air traffic control system, market analysis, environmental impacts, socio-economic impacts, political impacts, safety and security, financial analysis, regulatory and policy analysis, insurance, training and workforce requirements, networking, inter-modal analysis, administration, and public outreach. Other outcomes of Moussavi's work included twenty-four journal publications, conference proceedings, and presentations and six research reports on Small Aircraft Transportation System.

Dr. Moussavi continues to actively participate in NASA SATS Transportation Systems Analysis & Assessment Working Group (TSAA-WG) teleconferences and contribute to the transportation system assessment and analysis work conducted at LaRC. Moussavi is in regular contact with Stuart Cooke, Jr., who leads up that effort for NASA's SATS TSAA-WG team and Jeff Viken, who leads the SATS national model integration effort. Moussavi has worked to coordinate the research conducted by other team members, so that the team's diverse research projects contribute to the decision support model development efforts in Nebraska and at the national level.

John Bartle continued his work on economic and financial issues related to SATS implementation. His work has led to a number of research outcomes. Those that are most closely focused on SATS are conference papers presented to aviation audiences. One paper applies a microeconomic model to SATS to anticipate barriers to implementation. The other paper applies concepts from "new institutional economics" within a context of a federal system to address the question of the long-term sustainability of infrastructure. In both cases, Bartle attempts to present to industry audiences powerful social science models that speak to the larger questions regarding SATS. In a third paper related to SATS, Bartle examines the issue of procurement processes in state government. To the extent that much of what SATS portends to achieve in rural regions, state governments will be integral to the program's success. A better understanding of how state governments procure goods and services is an important step in understanding how this important stakeholder may or may not be able to accommodate SATS.

In an effort to achieve one of EPSCoR's larger goals – attracting external research support – Bartle submitted a grant proposal to broaden the scale of his previous efforts in the area of transportation finance and to solidify the efforts of the School of Public Administration to be a leader in this area of study. The objective is to improve contacts with organizations involved either as funders or producers of research on this issue. These include federal agencies, foundations, professional groups, state governments, and other universities. The long-term goal is to attract financial support congruent with SATS CRT interests and capabilities in transportation finance, leading to research that can improve the resource allocation of transportation infrastructure.

Bartle's research is producing findings that are critical for policy makers who are interested in sustainable transportation. To the extent that SATS offers a new approach to small community air transport, it is important that we carefully consider the broader policy implications for developing appropriate infrastructure, regulations, and mechanisms to finance the system beyond the initial phases of technology development and demonstration.

Brent Bowen contributed to the SATS team through his efforts on two projects including the CRT's analysis of security issues related to general aviation. It is clear that security issues are of increased operational and political importance in the current environment. Bowen continued his review of the SATS program's development and recommendations for future

direction and evaluation. Bowen, along with his graduate assistant, Nanette Scarpelini-Metz also explored the organizational transition from AGATE to SATS in an effort to understand lessons that can be learned from the AGATE experience and integrated into the successful development of the SATS consortium, which will consist of government, industry, and academic partners. A research fellowship was awarded to Scarpelini-Metz, who spent time at LaRC interviewing key participants in AGATE and SATS and collecting archival data related to the development of AGATE and the transition to SATS.

Aeronautics Education, Research, and Industry Alliance (AERIAL)
Research Area Award Request for Continuation for the

**Small Aircraft Transportation System (SATS)
Collaborative Research Team (CRT)**

I. Two-Year Program Plan and Budget

The Nebraska Small Aircraft Transportation System (SATS) Collaborative Research Team (CRT) has been working with NASA LaRC researchers for five years. From the earliest beginnings of the SATS initiative, the CRT has supported the NASA SATS project through its multifaceted research program. The CRT's research has played a significant role in the development of a comprehensive decision support system model, which now guides NASA researchers and aviation stakeholders in evaluating the potential impact of the SATS program. The CRT's research has also guided the development of the SATS concept. Our work on the potential impact of an air taxi business model as an alternative mode of transport for small and rural communities helps redefine the near term goals of the SATS program. More recently, we have been able to leverage the knowledge and experience gained through our EPSCoR work to compete successfully for non-EPSCoR grant funding. This work has studied rural and small community transportation needs and the ability and willingness of small airports to accommodate SATS aircraft and operations. In short, the efforts of the Nebraska SATS CRT continue to meet the goals of the EPSCoR program. We have worked closely and continuously with our NASA counterparts through the Transportation Systems Analysis and Assessment (TSAA) Working Group. We have secured non-EPSCoR funding for our research through our collaborative efforts with the Research Triangle Institute and the National Consortium for Aviation Mobility, which manages the public-private partnership that guides the bulk of SATS research heading towards the technology demonstration scheduled for 2005. We have been responsive to our NASA technical monitor and other NASA researchers. Our work has helped them close a variety of gaps in the collective knowledge about rural and small community air transport as well as the strategies for overcoming obstacles to the successful deployment of a transportation system based on advanced light aircraft.

Our proposal for the next two years of EPSCoR funding seeks to extend and refine some of our existing work as well as the development of a two new areas of research that have been suggested by our NASA technical monitor and our NASA point of contact within the TSAA. Bruce Holmes, Associate Director for Airspace and Vehicle Systems Integration, NASA Langley Research Center, will continue to serve as our technical monitor. We have worked with Bruce since the inception of the SATS program and his broad perspective on SATS and air transport more generally has provided our CRT with sound advice and guidance as our research program has evolved. We will also continue to work directly with Stuart Cooke, Transportation Systems Analysis and Assessment Lead for the SATS program at NASA LaRC. Members of our CRT have been in direct and frequent contact with Cooke over the last two years through regular weekly teleconferences and occasional face-to-face meetings. It would be reasonable to think of Holmes as our CRT's macro advisor and Cooke as our micro advisor. The combination of the two points of contact has proven to be very productive since our research agenda has developed in the context of the broader issues facing the future of air transportation and the more specific issues related to the implementation of the SATS concept.

The balance of this narrative provides specific details about the current members of the CRT, their proposed research, and how that research will address the complementary goals of responding to the needs and interests of our NASA colleagues and the mission of the EPSCoR program, which is to help our CRT build a solid foundation of knowledge and experience that will allow us to successfully compete for non-EPSCoR funding. The projects are broken down into substantive areas. The new projects are described in more detail than the on-going work. One or two CRT members head each area. The CRT's principal investigator, Scott Tarry, coordinates the combined effort. It is important to note that CRT members genuinely collaborate with one another within and between the projects proposed below. For example, the results of the work on insurance, economic development, and sustainable transportation will ultimately contribute to the refinement of the decision support model.

A. Systems Assessment and Decision Support Analysis – M. Moussavi, lead researcher

Building on the Nebraska-SATS decision support system sub-models completed in Years 1 through 3, Moussavi will forge ahead with the development, testing, calibration, and integration of the complete systems engineering management tool that is the centerpiece of his contribution to the CRT. It is anticipated that the effective use of Moussavi's model will aid the Nebraska State Aviation System Planners as they contemplate the improvements that need to be made to implement SATS in Nebraska. This state-centered approach to modeling SATS is an important contribution to the overall SATS project, because many of the critical decisions about infrastructure, finance, and program development will fall to decision makers at the state level. Moussavi's state-level analysis, while developed in the context of the state of Nebraska, will ultimately become a decision tool appropriate for other states around the country.

Moussavi continues to work with researchers at Virginia Tech, Research Triangle Institute, Team Vision, and the other members of the NASA SATS Transportation Systems Analysis & Assessment Working Group (TSAA-WG) to integrate the Nebraska SATS Decision Support Model (DSM) into the regional and national SATS-DSM. The ultimate product of Moussavi's work is the full integration of a variety of modeling and decision support tools, which will be available for NASA researchers to more fully assess the implementation of the SATS concept. The integrated model, which will be presented in a user-friendly graphical interface, will enable stakeholders to tailor the model's specific output to their own circumstances. Moussavi will provide the data and other materials from his work directly to Stuart Cooke at LaRC. Moussavi will continue his efforts to present and publish his work at appropriate professional conferences, such as the TRB, and relevant peer-reviewed transportation journals.

Moussavi will also continue his active participation in NASA SATS Transportation Systems Analysis & Assessment Working Group (TSAA-WG) teleconferences and contribute to the transportation system assessment and analysis work conducted at LaRC. Moussavi will be in regular contact with Stuart Cooke, Jr., who heads up that effort for NASA's SATS TSAA-WG team and Jeff Viken who leads the SATS national model integration effort. Moussavi's EPSCoR funded research is supporting NASA's efforts to develop a comprehensive decision support model. The experience and knowledge gained from his on-going collaborative work with the TSAA as well as specific NASA researchers have already allowed Moussavi to secure non-EPSCoR funding. The current work on model integration and calibration proposed for Years 4 and 5 of our EPSCoR funded effort will further prepare Moussavi for other non-EPSCoR funding opportunities.

B. Risk Assessment and Aviation Insurance: Implications for the SATS program – Scott E. Tarry, lead researcher

One of the important contributions of the Nebraska SATS CRT thus far has been to identify and analyze potential obstacles to the successful implementation of the SATS concept. While the primary focus of NASA researchers and their counterparts within NCAM has been the development of technologies that will make the proposed new aircraft safer, more reliable, easier to operate, and more affordable, scant attention has been paid to the regulatory, policy, and financial barriers to implementation of SATS as a bona fide system of transportation. At the behest of Bruce Holmes, the CRT's technical monitor, and Stuart Cooke, the TSAA Lead at LaRC, we have begun to address the issue of risk assessment and the role that aviation insurance might play in limiting the implementation of SATS. Our work has thus far resulted in a study of aviation insurance, which was presented at the Air Transport Research Society annual meeting and has subsequently appeared in the *Journal of Air Transport Management*.

CRT members Scott Tarry and Bassel Kasaby also convened a workshop on SATS and aviation insurance at the national meeting of the National Business Aviation Association, the leading industry group for light business and commercial aircraft in the US. Attended by representatives from the FAA, NASA, aviation insurance underwriters and brokers, and airframe manufacturers, the workshop served to identify areas of concern with the insurance community that might impede development of the SATS program. The meeting helped to establish a set of research questions or objectives. The CRT is now in a position to move forward with its work on aviation insurance and risk assessment in a way that is useful for both the NASA program as well as the industry in general. We expect that our effort will produce research outcomes that will further assist the TSAA Working Group as it refines and enhances the decision system support model. In particular, the CRT will assess a number of options for addressing the barriers posed by aviation insurance including, but not limited to, pilot training programs, risk pooling, and government subsidy.

Among the key operating capabilities for the SATS program are single-pilot operations and lower landing minima. NASA and industry partners are well on their way to achieving these technological objectives. It is important to remember, however, that the ultimate value of SATS will depend on translating these objectives into the air transport system. In other words, it is not sufficient merely to show that something can be done, it must also reach a level of acceptance within the regulatory community and the market. In the case of these new operational capabilities, the FAA and the insurance community will play important roles in determining the acceptance of single pilot operations and lower landing minima. At the behest of the CRT's technical monitor, we will explore the impact that single-pilot operations will have on the risk and the perception of risk, hence the insurability, of SATS operations. The CRT will continue to contribute its findings to the on-going discussions in the TSAA Working Group. It will also provide NASA with a report on the impact that insurance will have on SATS implementation. Finally, in addition to continuing to facilitate the dialogue between NASA and the insurance industry, the CRT will present and publish its finding in appropriate academic and professional venues.

C. Small Airports and Economic Development: Empirical Analysis and Evaluation – Robert Blair and Jerry Deichert, lead researchers

Transportation networks and facilities play a critical role in the economic development of communities. Transportation costs affect the location and growth of local businesses and serve historically as a primary industrial location factor. With limited access to other transportation

modes and networks, like rail or Interstate Highway systems, public-use airports in rural and non-metropolitan communities would appear to function as exceptionally important local economic development factors, especially in agricultural states and states with dispersed populations.

Past studies on industrial location and economic development looked at railroads, highways, and interstate interchanges among others as important development factors. Unfortunately, research on the economic impact of airports in rural and small communities is largely anecdotal and promotional. We propose to examine critically and systematically the role of airports and access to air transportation in the economic development of rural and small dispersed communities. In other words, what role do airports and air transportation play in rural and small community economic development? The answer to this question is essential for stakeholders attempting to evaluate SATS. This research will address an important concern for the TSAA Working Group and for policy makers who may need to make decisions about future funding of small community air transportation. One of the guiding principles of the SATS program and the work of the Nebraska CRT is that the success of SATS will be measured not simply in terms of its technological accomplishments, but also in terms of its real impact on mobility and economic development. To that end, Bruce Holmes, our NASA technical monitor, has charged us with providing rigorous empirical research in this area. Moreover, this line of research will provide key inputs for the ongoing decision systems support modeling effort undertaken within the TSAA Working Group.

To accomplish this research objective, the study will examine approximately 90 small airports in Nebraska. Located near the geographic center of the continent, Nebraska, with its strong agricultural economic base and its 535 widely dispersed communities, can serve as a good model and case study for examining the importance of airports and air transportation as an industrial location factor for rural economic development. Small airports and air transportation potentially could be very important in the economic development of isolated rural counties which lack access to the interstate highway system and are long distances away from major airports and hubs. Moreover, these communities have not benefited from the nation's air transport system, which is dominated by the scheduled airline business model.

This study proposes to proceed in two phases: quantitative and qualitative. The first phase will develop a quantitative model to address the relationship of airports and air transportation to economic development. Our model will build on existing studies of the impact of other modes. We will use county-level data from Nebraska and neighboring states, if possible, to analyze economic performance among counties to determine whether growth was influenced by the presence or absence of an airport and by the characteristics of the air transport services offered. Some of counties with all have access to other transportation modes (interstate interchanges) while others are limited to two-lane highways. We will analyze only those non-metropolitan counties where the largest town has a population of at least 2,500 persons. Economic development will be measured in terms of changes in employment, income, population, and the number of business establishments. The model will include other independent or explanatory variables including distance from and access to other transportation modes, including major airports; as well as the local economic and industrial structure.

Other indicators we use will be developed after we have completed our literature review on transportation and economic development. We intend to use a pooled cross-section time-series model in the analysis. The primary data source for the economic and population data will be the US Bureau of Economic Analysis, Regional Economic Information System. This

database has annual information from 1969 at the county level. We will collect airport-related data from existing state and local sources. In addition to the model described above, we may use an interrupted time-series model to look at the impact of the development of new airports in two cities in Nebraska within the last decade.

Phase Two will employ qualitative research methods, consisting of in-depth studies of a small number of communities in Nebraska. The researchers will generally collect data on-site in several communities. Case studies may be selected using criteria such as: communities that exceed or fail to achieve results expected from the model described above, and exceptional examples of the use of airports in new or emerging industries, or public-private partnerships and collaborations that engage airports or air transportation in economic development. Data collection will consist of interviews with key local public officials and business leaders, examination of comprehensive and airport plans, review of local economic development plans and policies, and other local sources of information.

The proposed study builds on research recently completed by the researchers that surveyed airport managers and airport board members, and inventoried the organizational structure and management of small airports. Among the items examined in this earlier study was the role of the airport in local efforts in community and economic development. It is anticipated that this research may make contributions to the literature on the industrial location and the importance of airports and air transportation to rural and small community economic development. The research methodology employed in this study should be readily replicable in other rural and dispersed population states.

One of the critical issues for stakeholders in rural and small communities is whether the investment to facilitate or accommodate SATS is going to provide a sufficient return on investment. The current literature on the impact of small airports and air transport services on small community economic development is largely anecdotal. Given the potential for SATS to revolutionize the way air transport services are provided to small communities, it is critical that we have a systematic understanding of the issues surrounding air transport and economic development. The research proposed here has the potential to answer questions specific to SATS while making a contribution to the broader literature on the impact of aviation on the nation's social and economic development. In the end, the CRT's data and analytical results on economic development will be delivered to the TSAA Working Group to address important stakeholder issues. The results will also help decision makers beyond SATS better understand the impact of air transport on small communities. These results will be presented at relevant industry and professional conferences. The results will also be published in appropriate transportation, economic development, and regional science journals.

**D. Social Efficiency and Transportation Investment: Is SATS sustainable? –
John Bartle, lead researcher**

While SATS can be defined narrowly as a technology program with the goal of bringing advanced technologies into light aircraft, it should also be thought of as a potentially revolutionary shift in the way people travel. If the aeronautical engineers can make these small airplanes do what has been proposed, then a variety of other critical issues emerge. In the area of infrastructure finance and transportation policy, the idea of sustainability has emerged as a focal point for scholars and policy makers alike. Once dismissed as radical and idealist, the idea of sustainable transportation has become firmly rooted in the discussions and debates about the future of transportation in America and around the world. In fact, the Joint Planning and Development Office (JPDO), which is preparing a plan for the next generation of the nation's air

transportation system, has included the concept of sustainability in its goals statement. Bruce Holmes, our CRT's technical monitor, serves on the JPDO and has reiterated the importance of these concepts. As such, we are proposing to include as part of our EPSCoR work a project related to sustainable transportation.

While the achievement of near-term improvements in mobility is clearly important, the long-term impact on the nation's economy and society will depend on how SATS is integrated into the broader transportation structure. Policy design should be focused on creating institutional structures to achieve sustainability. Because these institutions may need to be determined on a case-by-case basis, it is unlikely that centrally-determined policies will appropriately achieve efficiency. Instead of determining a nationally uniform structure, policy may best delegate this decision-making to the parties affected by the decision. This approach is most important when considering the influence of long-term transportation infrastructure investments. The existing design of institutions helps shape the range of incentives influencing actors. Actors respond to incentives in their decisions about infrastructure investments. The increasing returns to scale on technological and capital investments then create a path dependence that makes it difficult and expensive to alter that path. As a result, the productivity of social institutions may or may not be efficient in the long run; nevertheless, the institutional structure that created it tends to reinforce itself. The three variables -- institutions, incentives, and investments -- feed back to each other to create an endogenous web that charts an economic development path. If the incentives stimulate institutional actors to make socially inefficient investments, then over time economic development will be low or perhaps negative considering the negative effects of the taxes used to fund the expenditures.

A variety of changes will profoundly change technology and incentive patterns in the near future. They include:

- The potential of intelligent transportation systems and on-board computers allows for greater responsiveness to the needs of different types of motor vehicles and aircraft, and also allows for improved user charges.
- SATS is developing improved avionics and other technologies that will lower the cost of small aircraft to allow for higher degrees of personal and fractional ownership as well as air taxi systems that could by-pass the hub-and-spoke commercial air system.
- Declining ticket tax revenues and threats to the financial stability of major U.S. airlines draws into question the stability of the Airport and Airway Trust Fund.

The SATS project offers an opportunity to rethink the concept of air transportation as well as transportation policy more broadly. As evidenced by the attention received by the JDPO and the Transportation Research Board, the concept of sustainability is central to planning for the future of our nation's transport system. The work proposed here will achieve the two goals of the EPSCoR program. It will allow our CRT to contribute to the successful develop of the NASA initiated SATS program. It will also allow our CRT to gain knowledge and experience in the area of sustainable transportation, which will greatly enhance our ability to become self-sufficient at the conclusion of the EPSCoR funding period. The results of this analysis will be reported directly to the TSAA Working Group to help shape the dialogue between NASA and national and regional transportation decision makers. The results will also be presented and published in appropriate transportation conferences and journal outlets. While focused on SATS, this work has implications for a wide variety of transportation policy decisions. The CRT is confident that the experience gained through this component of its EPSCoR funded work will prepare it for non-EPSCoR funding opportunities in the near future.

II. Metrics for Tracking and Evaluating Program Progress

Three general metrics will be used to evaluate the progress of our proposed research. First, we will evaluate our progress in terms of our ability to provide answers to the stakeholder questions that have been posed by the TSAA Working Group. These questions provide clear targets for our analysis. We will work directly with Stuart Cooke in addressing the stakeholder questions and providing appropriate research outputs. Second, because we are interested in both the external validation and the scholarly contribution of our research, we will evaluate our progress in terms of the number of presentations given at professional meetings and the number of peer-reviewed articles generated from our research. We have had good results in the first three years of our EPSCoR funded research and expect that we will be able to continue at an appropriate pace during the funded period. Finally, we will continue to pursue the goal of self-sufficiency. We have already identified a number of external funding opportunities and hope to leverage our EPSCoR funded research in preparing successful applications for this funding.

III. Milestones & Timetables for Achieving Specific Objectives During Award Period

Given the varied nature of the work proposed it is difficult to provide specific milestones and timetables. We can, however, provide a general indication of our expected outputs for each of the two years of proposed projects.

A. Year 4

- Integration and calibration of Nebraska DSS model with national DSS model
- Assessment of alternative solutions for reducing or managing risk in the deployment of SATS as an on-demand air taxi system
- Quantitative analysis of economic impact of airports and air transport services on small rural communities
- Evaluation of the sustainability of small community air transport in its current forms

B. Year 5

- Applications of state-level DSS to other states in the Great Plains region
- Assessment of alternative solutions for reducing or managing risk in the deployment of SATS as a system based on aircraft flown by owner/operators.
- Qualitative analysis of specific illustrative cases of economic development success or failure determined in the broader quantitative modeling effort conducted in Year 4.
- Identification of specific policy issues related to the sustainability of the SATS concept

IV. Potential to Achieve Self-sufficiency Beyond the Award Period of This Grant

While the CRT has already achieved some success in securing non-EPSCoR funding as a result of the experience and knowledge gained from the first three years of our EPSCoR work, we have plans to further leverage our SATS research. Specifically, our work on decision support system modeling has applications beyond aviation. We believe that the further refinement of the DSS model offers opportunities to secure funding from state planning agencies and other policy makers seeking to allocate scarce transportation resources. The model is not limited to the SATS concept, which means that it has applications that extend beyond SATS and beyond Nebraska.

Our work on aviation insurance and risk management offers an opportunity to secure funding from a number of sources. Not surprisingly, the insurance industry is interested in working with operators to manage risk. While substantial progress has been made in corporate

aviation, for example, much less progress has been made among the burgeoning ranks of owner/operators. The latter group will become increasingly important in the risk pool if SATS reaches fruition. We believe that our work will help identify programs and processes that might help the industry deal with this important sector of the air transport market. We also believe there is an opportunity to attract funding from federal sources interested in enhancing aviation and transportation safety.

The work on economic development and sustainability offers the potential to secure funding from the National Science Foundation as well as other federal and state transportation agencies interested in better understanding the impact of transportation investment decisions. These parts of the proposed work range from very theoretical to specific applied research, so the opportunities for non-EPSCoR funding are considerable.

V. Potential for Future Growth in Importance in Aerospace Fields

As noted earlier, the overarching theme of the research proposed here is that while it is focused on SATS, it is not dependent on SATS. In other words, SATS is the specific subject of our inquiries here, but the contributions of the research extend beyond SATS and have implications for a broad spectrum of aviation and transportation issue. We expect that each of the four substantive areas of research will be important for decision makers and stakeholders grappling with issues related to the current and future systems of air transportation. We believe that the expertise and experience we gain from our EPSCoR funded activities will allow us to contribute to the further development of the air transport system at the state and national levels. Continued collaboration with NASA Langley's Dr. Bruce Holmes, Associate Director for Airspace and Vehicle Systems Integration, will ensure that Nebraska's vision remains aligned with that of NASA.

Attachment 1
Small Aircraft Transportation System
Cumulative Outcomes: 2001-2004

- Bartle, J. (in press). Transportation infrastructure. *Handbook of Public Sector Economics*.
- Bartle, J., & Korosec, R.L. (in print). A review of state procurement and contracting. *Journal of Public Procurement*, 3.
- Bowen, B. & Scarpellini-Metz, N. (in print). AGATE outcomes analysis: Laying the foundation for SATS. *Journal of Aviation/Aerospace Education and Research*.
- Bowen, B. & Scarpellini-Metz, N. (in review). A research case study: Exploring the influence of AGATE. *Public Works Management and Policy*.
- Holmes, B., Tarry, S., & Durham, M. (in review). The Small Aircraft Transportation System (SATS) concept. *Journal of Aircraft*.
- Moussavi, M., & Vargas, J., (in review). Planning and design of Small Aircraft Transportation System (SATS) in Nebraska. *ASCE Journal of Transportation Engineering*.
- Tarry, S., Vlasek, K., & El-Kasaby, B. (in review). Aviation insurance and the implementation of the Small Aircraft Transportation System (SATS) [Special issue]. *Journal of Air Transport Management*.
- Moussavi, M. (2004, April 16). Application of SATS modal choice analysis computer program. [Abstract]. *Proceedings of the 124th Annual Nebraska Academy of Sciences*: Lincoln, NE, 21-22.
- Moussavi, M., & Vargas, J. (2004, January). Small Aircraft Transportation System modal choice analysis. *Proceedings of the 83rd Annual Meeting of the Transportation Research Board*: Washington, DC, Compendium of papers (CD-ROM), 1-17.
- Bartle, J., & Swayze, R. (2003). *Reforming airport finance: Improving infrastructure investment*. Unpublished manuscript.
- Moussavi, M., & Vargas, J. (2003). Small Aircraft Transportation System as implemented in Nebraska. *Journal of the Transportation Research Board*, 1850, 11-19.
- Moussavi, M. (2003, December 11). Small Aircraft Transportation System (SATS): Nebraska Implementation. Research presented to the National Aeronautics and Space Administration, Hampton, VA.
- Moussavi, M. (2003, December 11). Small Aircraft Transportation System (SATS). Research presented at the Transportation Systems Analysis & Assessment and NASA SATS

Technical Coordinating Committee Meeting, NASA Langley Research Center: Hampton, VA.

- Holmes, B., Tarry, S., & Durham, M. (2003, July). The Small Aircraft Transportation System (SATS) concept. Paper accepted for presentation at the AIAA-ICAS International Air & Space Symposium and Exposition, Dayton, Ohio.
- Tarry, S.E., & Moussavi, M. (2003, June). Implementing SATS in the Upper Great Plains. Research Report submitted to North Carolina/Upper Great Plains SATS Lab and Transportation Systems Analysis and Assessment Working Group, NASA Langley Research Center: Hampton, VA.
- Moussavi, M. (2003, April 25). Small Aircraft Transportation System Research Progress Report. Research presented at the NASA Nebraska Space Grant & EPSCoR Technical Advisory Committee TAC Meeting: Lincoln, NE.
- Bartle, J. (2003, April 25). The sustainable development of transportation infrastructure: An institutional perspective [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27-28.
- Bonkiewicz, T., & Bowen, B. (2003, April 25). General aviation security issues Impacting the Small Aircraft Transportation System in the post 9-11 environment [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*, 28.
- Metz, N., & Bowen, B. (2003, April 25). AGATE/SATS: A case study in federal program management. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 23.
- Moussavi, M. (2003, April 25). Decision support model for implementing Small Aircraft Transportation System (SATS) in Nebraska [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27.
- Tarry, S., Vlasek, K., & El-Kasaby B. (2003, April 25). A comparison of the Small Aircraft Transportation System to existing transportation system options in Nebraska [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 27.
- Tarry, S., Vlasek, K., & El-Kasaby B. (2003, April 25). Aviation insurance and the implementation of the small aircraft transportation system [Abstract]. *Proceedings of the 123rd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 34.
- Tarry, S. (2003, April). *Alternatives to Essential Air Service (EAS) and public service obligation routes: Air transport in remote regions*. Paper presented at the 3rd Annual Forum on Air Transport in Remote Regions, Cork, Ireland.
- Bartle, J. (2003, March). *A two-sector economic model of technological progress in air transportation: Implications for public investment*. Poster session presented at the annual

meeting of the NASA Experimental Program to Stimulate Competitive Research Program, Washington, DC.

- Tarry, S. (2003, March). Air transportation in rural communities. Paper presented at Annual Meeting of the American Society for Public Administration, Washington, DC.
- Tarry, S. (2003, March). *Policy options for rural America: Comparing the Small Aircraft Transportation System (SATS) and the Essential Air Service (EAS)*. Paper presented at the Annual Meeting of the American Society for Public Administration, Washington, DC.
- Tarry, S., Bartle, J., & Moussavi, M. (2003, March). *Small Aircraft Transportation System (SATS): Research collaborations with the NASA Langley Research Center*. Poster session presented at the annual meeting of the NASA Experimental Program to Stimulate Competitive Research Program, Washington, DC.
- Tarry, S., Bartle, J., & Moussavi, M. (2003, March). Implementing SATS in Nebraska. Paper presented at the annual meeting of the NASA Experimental Program to Stimulate Competitive Research Program, Washington, DC.
- Tarry, S., & Bonkiewicz, T. (2003, March). *Assessing the role of privately owned public use airports*. Paper presented at the Annual Forum of the Transportation Research Forum, Washington, DC.
- Moussavi, M., & Vargas, J., (2003, January 12-16). Small Aircraft Transportation System (SATS): Nebraska implementation. Research presented at the 82nd Annual Meeting of Transportation Research Board: Washington, DC, 1-18.
- Nickerson, J., Moussavi, M., Smith, R., Tarry, S., & Bowen, B. (2002). Innovatively saving the future of transportation: The Small Aircraft Transportation System (SATS). *Journal of Public Transportation*, 5(3), 67-82.
- Bonkiewicz, T., & Bowen, B. (2002, October). Analytic assessment of general aviation security issues in the Post 9-11 environment: Implications for the Small Aircraft Transportation System (SATS). *Collegiate Aviation Review*, 20(1), 17-28.
- Tarry, S., & Moussavi, M. (2002, October, 29). Implementing the Small Aircraft Transportation System (SATS) in Nebraska and the Great Plains states. Paper presented to the Transportation Systems Analysis and Assessment Working Group, NASA Langley Research Center.
- Fink, M., Bowen, B., Tarry, S., et al. (2002, September). *The upper Great Plains Small Aircraft Transportation System (SATS) plan*. Paper presented at the Western Region NASA Space Grant Conference, Big Sky, MT.

- Moussavi, M. (2002, September 25-27). NASA's Small Aircraft Transportation System (SATS). Research presented at the Missouri Valley Section of the Institute of Transportation Engineers (MOVITE) Annual Meeting: Omaha, NE.
- Moussavi, M. (2002, August). A systems engineering approach for managing Small Aircraft Transportation System (SATS) planning, design, and operations. Paper presented to the National Aeronautics and Space Administration (NASA), Hampton, VA.
- Bowen, B., & Metz, N. (2002, July). Policy research, a case in agency transition: The NASA AGATE/SATS program. *Proceedings of the Air Transport Research Society International Conference*. Seattle, WA.
- Tarry, S., Vlasek, K., & El-Kasaby, B. (2002, July). Aviation insurance and the development of advanced small aircraft. *Proceedings of the Air Transport Research Society International Conference*. Seattle, WA.
- Tarry, S., Moussavi, M., El-Kasaby, B., et al., (2002, June). Implementing the Small Aircraft Transportation System (SATS) in Nebraska. Research findings presented to North Carolina/Upper Great Plains SATS Lab.
- O'Neil, P., & Bowen, B. (2002, May). *Enabling technologies for the Small Aircraft Transportation System (SATS), an annotated bibliography*. (UNOAI Report 02-3). Omaha, NE: University of Nebraska at Omaha Aviation Institute.
- Bowen, B. (2002, April). *Collegiate aviation education: Opportunities through research, the SATS 101 example*. National Congress on Aerospace Education, Washington, D.C.
- Metz, N., & Bowen, B. (2002, April 26). Policy research results from a retrospective assessment of the NASA AGATE program: Implications for NASA SATS [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 22.
- Moussavi, M. (2002, April 26). An inventory study of the potential Small Aircraft Transportation System landing facilities in Nebraska [Abstract]. *Proceedings of the 122nd Annual Nebraska Academy of Sciences*: Lincoln, NE, 22-23.
- Moussavi, M. (2002, April 26). Small Aircraft Transportation System research progress report. Research presented at the NASA Nebraska Space Grant & EPSCoR Technical Advisory Committee (TAC) Meeting: Lincoln, NE.
- Tarry, S., El-Kasaby, B., & Vlasek, K. (2002, April). *New technologies and policy change: Advanced small aircraft and rural transport*. Paper presented at the Annual Meeting of the Midwest Political Science Association, Chicago, IL.
- Tarry, S., & El-Kasaby, B. (2002, April 26). Technology-based solutions for rural transportation: The Small Aircraft Transportation System (SATS) [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 22.

- Tarry, S., & Vlasek, K. (2002, April 26). An examination of insurance issues surrounding the Small Aircraft Transportation System (SATS) [Abstract]. *Proceedings of the 122nd Meeting of the Nebraska Academy of Sciences*: Lincoln, NE, 23.
- Bowen, B. (2002, March). SATS research update, Aerospace Technology Working Group (ASTWG) session. *Research presented at the National Council of NASA Space Grant Directors Meeting, Washington, D.C.*
- Bowen, B. (2002, March). SATS research update, Aerospace Technology Symposium 2002. *Research presented at the National Council of NASA Space Grant Directors, Aerospace Technology Working Group, NASA White Sands Research Facility, NM.*
- Moussavi, M. (2001). *SATS system dynamics modeling*. Research presented at the SATS Systems Engineering Workshop. NASA Langley Research Center: Hampton, VA.
- Bowen, B., & Metz, N. (2001, October). The policy research construct: Applications to aviation and space research. [Abstract] *Research Roundtable, Fall Conference of the University Aviation Association*. Nashville, TN.
- Bowen, B., & Tarry, S. (2001, October) Identification of public policy perspectives in the deployment of the Small Aircraft Transportation System (SATS). *43rd Annual Proceedings of the Transportation Research Forum*, 1-8.
- Bowen, B. & Tarry, S. (2001, October). *Identification of public policy research applications in the deployment of a new air transportation system component*. Paper presented at the Annual Meeting of the Transportation Research Forum, Williamsburg, VA.
- Bowen, B. (2001, August). *Nebraska Small Aircraft Transportation System (SATS) work-plan update recommendations*. Paper presented at the SATS Leadership Team Meeting at NASA Langley Research Center, Hampton, VA.
- Tarry, S., & Bowen, B. (2001, August). *The Nebraska work plan for SATS Research* [Abstract]. Presented at the meeting of the Research Triangle Institute SATS Forum. Raleigh, NC.
- Moussavi, M. (2001, April 20). A framework for developing a decision support simulation model for Small Aircraft Transportation System [Abstract]. *Proceedings of the 121st Annual Nebraska Academy of Sciences*: Lincoln, NE.
- Moussavi, M. (2001, April 19-20). A framework for developing a decision support simulation model for Small Aircraft Transportation System [Abstract]. *Proceedings of the 121st Annual Nebraska Academy of Sciences*: Lincoln, NE.
- Moussavi, M. (2001, April 19). A systems engineering approach for managing Small Aircraft Transportation System (SATS), Research presented at the Annual Meeting of the Nebraska Section of the American Society of Civil Engineers: Omaha, NE.

Moussavi, M. (2001, February 20). *A framework for developing a decision support simulation model for Small Aircraft Transportation System*. Research presented to the National Aeronautics and Space Administration, NASA Langley Research Center: Hampton, VA.

Moussavi, M. (2001). A systems engineering approach for managing Small Aircraft Transportation System planning, design, and operations. Research presented to the National Aeronautics and Space Administration: Hampton, VA.

Graduate Degrees Conferred

Vargas, J. A. (2002, May). Small Aircraft Transportation System: Nebraska implementation. Unpublished master's thesis, University of Nebraska-Lincoln, Lincoln, NE.

El-Touny, S. (in progress). Decision support model for implementing Small Aircraft Transportation System (SATS) in Nebraska, Unpublished master's thesis, University of Nebraska-Lincoln, Lincoln, NE.

Vargas, J. (in progress). Small Aircraft Transportation System. Unpublished doctoral dissertation, University of Nebraska-Lincoln, Lincoln, NE.

Additional Research 2001-2004 Activities

1. Established points of contact with NASA researchers at Langley and Ames Research Centers.
2. Served as a member of the NASA SATS Transportation Systems Analysis & Assessment Working Group (TSAA-WG), and actively participated in their weekly teleconferences through Web-Ex.
3. Supported SATS research by active participation in NASA's Systems Engineering Team work at Langley, and UNO Aviation Institute's research activities.
4. Reviewed research reports and documents for NASA SATS Transportation Systems Analysis & Assessment Working Group (TSAA-WG) at NASA Langley Research Center.
5. Participated in the NASA Langley Research Center SATS-TSAA Workshop for collaborative research work with NASA scientists and researches, February 17-19, 2004.
6. Participated in the 83th Annual Meeting of Transportation Research Board in Washington, D.C., January 11-15, 2004.
7. Participated in the NASA Langley Research Center SATS-TSAA Workshop for collaborative research work with NASA scientists and researches, December 11, 2003.
8. Participated in the 82th Annual Meeting of Transportation Research Board in Washington, D.C., January 12-16, 2003.
9. Participated in the 81th Annual Meeting of Transportation Research Board in Washington, D.C., January 13-17, 2002.
10. Visited NASA Langley Research Center in Hampton Virginia, for collaborative research work with NASA scientists and researches, August 4-6, 2002.
11. Visited NASA Ames Research Center in San Jose California, for collaborative research

- work with NASA scientists and researches, July 7-10, 2002.
12. Participated in the 80th Annual Meeting of Transportation Research Board in Washington, D.C., January 7-11, 2001.
 13. Participated in the SATS Systems Engineering Work Package (SSEWP) Workshop to Develop "SATS National Decision Support Simulation Model Framework", NASA Langley Research Center, Hampton, Virginia, January 22, 2001.
 14. Participated in the Small Aircraft Transportation System (SATS) Technical & Partnering Workshop, sponsored by NASA Langley Research Center, Omni Newport News Hotel in Newport News, Virginia, January 23-24, 2001.
 15. Participated in the SATS Systems Engineering Work Package (SSEWP) Workshop to Develop "SATS National Decision Support Simulation Model Framework", NASA Langley Research Center, Hampton, Virginia, February 19-21, 2001.
 16. Assisted in preparing a Research Proposal entitled "Exploring the Impact of SATS on the Great Plains Region" as part of the joint proposal with Research Triangle Institute (RTI) to National Aeronautics and Space Administration (NASA), April 26, 2001.
 17. Participated in the Research Symposium at NASA Langley Research Center, Hampton, Virginia, May 17-19, 2001.
 18. Continued to support the graduate program at the University of Nebraska-Omaha Aviation Institute by active participation in their research and scholarly activities and graduate student support.